SIXTH ANNUAL REPORT

of the

AID-ARS Project

US agency for International Development

U.S. Agricultural Research Service

Major Cereals in Africa

1969

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AID-ARS Project

Major Cereals in Africa

G. F. Sprague

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INTRODUCTION

This report will include: (1) current status of the Project, (2) a detailed report of the activities of the individual scientists and (3) a brief summary of accomplishments.

Current Status

This AID-ARS project was authorized in 1963 under PASA AID/Res 20. The initiation of research activities was delayed due to: (1) problems in obtaining formal approval of the African Governments involved, (2) the unavailability of local housing, and (3) difficulties in recruiting competent staff. The first staff assignments were made in July and September 1964.

The program, as initially outlined, has three major objectives: (1) to increase cereal production in Africa through cooperation with and support to research organizations in Nigeria, Kenya and Uganda, (2) to stimulate and sponsor cooperative research on all aspects of crop production throughout the area, and (3) to provide in-service training at the headquarter stations, to individuals sponsored by their respective governments.

Regional centers were established in West and East Africa to serve the differing ecological situations. In West Africa the sponsoring agency is STRC authorized by OAU. Nigeria serves as the host country with centers located at Ahmadu-Bello University, Institute for Agricultural Research, Zaria, and the Federal Department of Agricultural Research, Moor Plantation, Ibadan. Staff at the first location is concerned with sorghum, millet and maize breeding, insect and disease control and soil-water-fertility-plant relations. Work at the Federal Department of Agricultural Research is limited to maize breeding and pathology.

In East Africa the sponsoring agency is EAAFRO. Research work is concentrated at three locations: Soroti Experiment Station, Uganda; the National Agricultural Research Station, Kitale, Kenya; and the East African Industrial Research Organization at Nairobi, Kenya. Work at Soroti is concerned with sorghum and millet breeding, soil-water-fertility-plant relations, and insect control. The work at Kitale is concerned with maize breeding and production. Work on cereal milling and processing, with primary emphasis on sorghum, was initiated in 1968 at Nairobi, Kenya.

It was the original intent that our research activities would supplement and strengthen ongoing research activities. Our operational procedure, therefore, has been to develop local cooperation to the maximum degree possible and to establish new research in subject matter areas receiving limited research emphasis. For this reason reporting will include research done by our staff and by other scientists with whom we have cooperative relations. The attempt will be to provide as comprehensive a picture as possible of current research on cereals. Authorship of sections will indicate the affiliation of the scientists involved.

The location of the current and proposed staff is as follows:

Name	Discipline	When Posted	Location
O.J.Webster 1/	Geneticist and Coord. STRC	Sept. 1964	Inst. for Agr. Res. Zaria, Nigeria
S.B.King 2/	Plant Path.	April 1967	" "
G.T.York 2/	Entomologist	Febr. 1966	" "
K.R.Stockinger 2/	Soil Scientist	June 1966	" "
J. Craig 2/	Maize Path-Breeder	Sept. 1965	Federal Res.Sta. Ibadan, Nigeria
G.A.Schumaker 2/	Soil Scientist	May 1966	Soroti Agr.Exp.Sta. Serere, Uganda
L.V.Peters 2/	Millet Geneticist	March 1967	" "
Dean Barry	Entomologist	June 1969	" "
L.H.Penny	Maize Geneticist	Nov. 1968	Nat'l. Agr. Exp.Sta. Kitale, Kenya
Allan Shepherd	Cereal Technologist	July 1968	EAIRO, Nairobi, Kenya
____________ 3/	Agronomist		Tanzania
____________ 3/	"		Uganda

1/ Now serving third tour of duty
2/ Now serving second tour of duty
3/ Included in FY-69 budget but no authorization for staffing from EAAFRO

Actual and proposed changes in policy deserve inclusion as background information. The original PASA was funded by AID/TCR (now Bureau of Technical Assistance, Office of Agricultural and Fisheries). In FY-69 funding of the East Africa segment was assumed by the Agriculture Division of the African Bureau. Beginning July 1, 1969 the same agency also provided the financial support for the West Africa segment.

Efforts have been underway, almost from the inception of this project, to expand the East Africa segment to include all of Eastern Africa. Following the Cummings report a detailed study and evaluation of EAAFRO was undertaken. This is still underway and no general policies have yet emerged. Until such time as an organizational structure is established and regional cooperation achieves some formal status, our contributions to an enlarged Eastern Africa operation will be limited largely to the conduct of regional trials, the identification and supply of promising breeding stocks, and support for the Eastern Africa Cereal Workers Conferences.

There is a general need for strengthening of the training function. The facilities for in-service training have been used primarily by the host country. Even in these cases tenure has been so short that counterpart status has been achieved for none of the positions. Much greater emphasis needs to be placed on professional training. Funds to support such a program were not available during the time the project was funded by AID/TCR. Under the current AID sponsorship funds for advanced training are included in the operating budget.

Arrangements have been made with Makerere University in East Africa and Ahmadu-Bello University in West Africa to participate in a graduate training program. The operational details visualized are as follows:

1. The University would have a voice in the selection of the candidate and in the course of study to be followed.

2. The candidate would spend sometime as a technician to determine whether he has a real interest in research and to establish his acceptability to the research supervisor.

3. Following (1) and (2) the candidate would enroll at some U.S. or European University for a period of 12-18 months in a prescribed course of study. Following this he would return to

the sponsoring research institution for the conduct of thesis research. This would ensure that thesis research has some relevance to the Agricultural needs of the area.

4. The degree would be granted by the participating African University.

5. Upon completion of the degree it would be expected that the individual would remain in the research program of his country for some specified period.

The first candidates under this program may be available in the fall of 1970.

WEST AFRICA

Sorghum, Maize and Millet Breeding
O. J. Webster

The staffing pattern of the cereals improvement program in Nigeria is the same as reported in 1968. Ayo Abifarin returned to Kano in June after being granted a Ph.D. degree by Purdue University. He has resumed the responsibility of improving sorghums for the Sudan Savanna region of Nigeria. Mr. Andrews, located at the Institute for Agricultural Research at Samaru, is responsible for the over-all sorghum program for Nigeria with a special interest in developing varieties for the northern Guinea Savanna. Dr. B. Bhardwaj is the leader of the millet improvement program and is posted at Kano. Andrews and Webster cooperate in the millet program by growing small nurseries at Samaru. Dr. Craig, maize pathologist of the Major Cereals Project, conducts research in maize pathology and breeding at the Federal Department of Agriculture Research at Ibadan and also coordinates the regional maize trials for west Africa. U. Ebong, now the Assistant Director of the Federal Research Station, Ibadan is responsible for the National Zonal Maize trials of Nigeria. Dr. Henry Wiggin, USAID maize breeder for the Western State has taken the lead in developing high lysine maize varieties. Franz de Wolff has completed his third season as maize breeder at Mokwa located about midway between Ibadan and Samaru. Dr. O. Webster is Coordinator-Director of the Project known as Joint Project 26 under the Organization of African Unity (OAU) Scientific Research Commission (STRC). He is directly responsible for coordinating the sorghum and millet regional trials of west Africa, the maize improvement project at Samaru and assists Dr. Abifarin in the development and testing of early maturing sorghum varieties.

The cereal breeders work as a team. Frequent meetings are held to disucss the results of the past years' work and to develop plans for the future. The contribution which each of the staff has made to this report gives a complete outline of the crop improvement work in progress and is appreciated.

Regional Activities - Cereal Conference.

The Third African Cereals Conference sponsored by OAU-STRC, Joint Project 26 was held at the Ahmadu Bello University, Institute for Agricultural Research, Zaria, Nigeria October 13-16. The first Conference was held at IAR in October 1965 with delegates coming from nine African countries. The second conference planned for Ibadan in July 1967 was cancelled a few days before it was to convened.

The Conference papers are translated, and printed by STRC in its publication African Soils (Sols Africains). Those from the 1965 conference appear in Vol. XI, No. 1 & 2, January-August 1966, and those which were to have been given at Ibadan in 1967 are printed in Vol. XII, No. 2 & 3, April-December 1967.

The official announcement for the Conferences are sent to governments affiliated with OAU by the Executive Secretary of STRC. The governments responded in 1969 by sending 70 delegates and observers from 19 countries; Botswana, Camerouns, Chad, Congo Kinshasha, Central African Republic, Gambia, Kenya, Mali, Niger, Nigeria, Senegal, Sierre Leone, Sudan, Uganda and Togo. Dahomey and Upper Volta were represented by J. LeConte, Chief Investigator of Maize and Millet for the Institute for Tropical Agricultural Research (IRAT) with headquarters in Paris, France. The travel plans for the delegate from Algiers were cancelled at the last minute. Other east Africa countries acknowledged the announcement of the meeting but did not feel it essential to send delegates since they had participated in the East African Cereals and Legume conference in April. Observers and delegates from outside Africa came from U.S. of America, India, Switzerland and France.

One of the reasons for holding the third conference at Zaria was to demonstrate the improvements through breeding which have been made in sorghums over the past four years. The sorghum breeding program by hybridization was initiated six years ago and in that period of time a number of improved varieties have been developed. The first day of the conference was devoted to a

field tour of the research projects at the Institute. In addition to visiting the maize and sorghum projects, stops were made at the cotton and groundnut breeding plots since these are the major cash crops grown in many African Countries. The principle investigators for these two crops held private discussions with interested delegates during the conference. The delegates were also able to see and discuss some of the work being conducted on the use of herbicides for weed control. The time planned for additional field tours was used to accommodate the papers given by the delegates. When the agenda was drafted it was not visualized that the number of delegates would be more than double those of previous conferences.

A list of papers and authors is as follows:

Eckebil, J. P. CAMEROUN
Work on Planted out Muskwari sorghums at the IRAT Station in North Cameroun.

Eckebil, J. P. CAMEROUN
Improvement of Cereals in Cameroun.

Tardieu, M., and J. Y. Praquin CAMEROUN
Improvement of Maize in Cameroun.

Vaille, J. CAMEROUN
Fertilization of sorghums in North Cameroun.

Breniere, J. FRANCE
Entomological research on sorghum and millet in French-speaking West Africa.

Delassus, M. FRANCE
Observations on sorghum disease in 'maggia' soils.

Marenah, L. J., and I. R. Hancock GAMBIA
A report on _Sorghum_ _bicolor_ (L.) Moench in the Gambia.

Akposoe, M. K. GHANA
Maize improvement in Ghana.

Koli, S. E. GHANA
Agronomy on Cereal Crops in Ghana.

Mercer-Quarshie, H. GHANA
Sorghum and millet Improvement in Ghana.

House, Leland INDIA
Collection, Problems and Uses.

Murty, B. R. INDIA
Analysis of adaptation of world collection and new hybrids of sorghum and Pennisetum.

Njuguna, S.K. KENYA
The possible application of S_1-testing for prolificacy in maize.

Bono, M. MALI
Maize - Prospects - Results.

Bono, M. MALI
Pennisetum millet and sorghum - synthesis of results.

Bono, M., and L. Soumare MALI
Pennisetum and sorghum - the options.

Kpengbe, Pierre and J. Nimezimabi CONGO
Report of cereal production in Central African Republic.

Nabos, J. NIGER
The present state of experimental work on millet and sorghum.

Craig, J. NIGERIA
Nigerian maize composite program.

Craig, J. NIGERIA
West African maize trials.

Ebong, U. U., and K. R. Raghunathan NIGERIA
Factors affecting acceptability of maize varieties in Nigeria.

Ekpenyong, T. A. NIGERIA
Some characters in high lysine corn.

Ekpenyong, T. A., and B. K. Ogunmodede NIGERIA
Comparative evaluation of local and opaque-2 maize.

Sobulo, R. A. NIGERIA
The use of soil analysis in fertilizer recommendations for cereals.

Wiggin, H. C. NIGERIA
Improving protein quality in maize.

Abifarin, A. O. and P. C. Pickett NIGERIA
Combining ability and heterosis for yield, protein, lysine and certain plant characters in 18 diverse inbreds and 56 hybrids in Sorghum bicolor (L.) Moench.

Bhardwaj, B. D. NIGERIA
Present status of pearl millet improvement in Nigeria.

deWolff, F. NIGERIA
The maize program in Mokwa

Andrews, D. J. NIGERIA
Progress in sorghum breeding in Nigeria.

Andrews, D. J. NIGERIA
Double cropping and intercropping with sorghum.

Caswell, H. NIGERIA
The storage of cereals in the northern states of Nigeria.

King, S. B. NIGERIA
Sorghum and millet pathology.

Stockinger, K. NIGERIA
Environmental factors limiting yield of the major cereals in northern Nigeria.

Webster, O. J. NIGERIA
The maize program at Zaria.

Webster, O. J. NIGERIA
Regional sorghum trials 1968.

York, G. T. NIGERIA
Recent developments regarding insects of cereals.

Odelola, A. O. NIGERIA
Address delivered by the Executive Secretary of the OAU/STRC

Etasse, C. SENEGAL
Improvement of Pennisetum millet at CRA Bambey: present work and trends.

Poulain, J. F., and R. Tourte SENEGAL
Influence of deep preparation of dry soil on responses to nitrogenous fertilizer in millets and sorghums (sandy soils of the dry tropical zone).

Inman, L. L.   SIERRE LEONE
Variety trials and observations of the production problems for maize, sorghum and millet in the humid tropics of Sierre Leone.

Mahmound, M. A. SUDAN
Outline of sorghum breeding in the Sudan.

Delcasso, G. TOGO
Summary on maize in Togo.

Doggett, H. UGANDA
The application of modern plant breeding methods to mainly self pollinated crops.

Rubaihayo, E. B. (Mrs.) UGANDA
Maize breeding in Uganda.

Eberhart, S. A. United States of America
Factors effecting efficiencies of breeding methods.

Burton, G. W.   United States of America
Genetic mechanisms of cytoplasmic male-sterility.

Pickett, R. C. United States of America
Protein and yield research in sorghum.

Following the presentation of papers and reports the Director-coordinator called upon the delegates of the conference to meet as an Advisory Committee and consider a series of recommendations.

Those presented and approved included:

1. that conferences should be rotated between countries of west Africa, since this project is regional.

2. that the next conference be held the last half of 1971.

3. that considering there are numerous complex problems which limit crop production and all of these cannot be adequately covered at one conference, the theme of the next conference should emphasize soils and soil management problems.

4. that more emphasis be given to scientific and technical papers at the conference and a minimum of time devoted to routine reports.

5. that government be encouraged to continue training agronomic specialists who will be responsible for increasing the production of cereals through the development of improved varieties with higher yield potential, resistance to diseases and insect pests, and for the development of better methods of crop husbandry.

6. that governments be encouraged to expedite their agricultural extension programs in order to take the fullest advantage of the development and recommendations of the specialists.

7. that governments be encouraged to develop seed multiplication and distribution schemes.

8. that since pulses are included in the area of responsibility of JP 26, personnel be added to the staff to implement this phase of work, and

9. that a newsletter pertaining to cereals be inaugurated among the specialists of Africa under OAU-STRC.

After the presentation of the recommendations, Mr. Odelola, Executive Secretary of OAU-STRC, commented in his closing remarks the value of specialists from the different countries visiting one another. He suggested that his office may be in a position to assist in defraying the expense of such travel if called upon. He also commented that OAU-STRC could give financial assistance for training specialists.

Regional Travel

In addition to local travel within Nigeria, members of the staff from Samaru traveled to Niger, Cameroun, Ghana, Zambia, Malawi, Kenya, Uganda and India.

Drs. O. J. Webster and J. Craig attended the East African Cereals and Grain Legumes Conference held in Zambia and Malawi, March 10-14. Agricultural research and the extension services in these two countries appeared to be relatively well advanced. Farmers were getting good crop yields when seed of improved varieties was planted and good husbandry used. Stops on the return trip were made in Nairobi where the operations of the east African Major Cereals Project were reviewed with members of the AID staff, and at Kitale, Kenya and Serere, Uganda.

O. Webster, S. King and A. Abifarin went to Niger in August to visit the Agricultural Stations at Tarna and Kawara. The Kawara station is located in the Tarka Valley where thesoils are heavy and are capable of producing high yields of sorghum. For the past three years a disease thought to be caused by a _Fusarium_ caused a near crop failure in the area. In 1969 an elaborate set of experiments was planned to study possible control measures. Major Cereals contributed seed of a collection of sorghum varieties to observe their reaction to the disease. Contrary to expectations there was no disease this year. Seedlings in the data of planting trial were doing poorly but were found to be infested with shoot fly. Based on the description of the disease in previous years it appears that it may be closely related to "pokkah bong" or "top rot" caused by _Fusarium moniliforme_. The disease symptoms included a tendency for the leaves to cling together rather than unfurl, resulting in a bowing of the upper portion of the plant followed by a rotting of the stalks and leaves.

G. York traveled to Ghana September 13-20 to consult with the entomologists at the Crops Research Division at Kumasi and Tamale. The insect problems in Nigeria and Ghana are similar and exchange visits of staff are of value.

In September O. Webster and S. King were invited to attend an international downy mildew conference in Pantnagar, India. Most of the delegates were from east and southeastern Asia countries. King read a paper "Downy mildew of sorghum in Nigiera". This disease has not been observed on maize in northern Nigeria but cause losses in nearly all millet fields.

In late October O. Webster, B. Bhardwaj and Brian Beck, agricultural specialist for the Ford Foundation, visited the research stations at Guetale and Maroua in the northern Camerouns. Our host was J. Eckebill cereal breeder who had spent three weeks in in-service-training at Samaru in 1968. Eckebill has made an extensive collection of sorghums in the Camerouns and had about 800 growing at Guetale. After he has calssified the collection, seed of distinct types will be sent to Samaru. Eventually seed will be sent to India and added to the World Sorghum Collection.

In response to a request by USAID/Congo (Kinshasha) Dr. Craig visited the Congo from January 15 to January 23, 1969. The purpose of the visit was to determine possible sites for maize yield trials and to observe problems and potentials of maize production in the area of the lower Congo lying between Thysville and Matadi.

The sites selected for yield trials were:

(1) Mwanzi INEAC Station

Several acres of G.P.S. 2 maize were observed at this station, the plantings were about 80 days old and it was estimated that yields of the best acreage would exceed 3000 lbs. of grain per acre. This maize had been fertilized at the rate of 134 kg. of ammonium sulfate, 63 kg of triple superphosphate and 53 kg. of potassium sulfate per hectare. The symptoms of nitrogen deficiency exhibited by these plots indicated that higher levels of nitrogen fertilizers would have increased yields.

(2) Jules Van Lanker Ranch

This is large livestock and plantation crop enterprise located near Thysville. Mr. Wissock, the Manager, is extremely interested in the possibilities of maize and sorghum production to supply livestock feed.

(3) Gimbi INEAC Station

This station is used for seed production of improved varieties of food crops. Growth of maize at this station had been severely retarded by drought and low soil fertility.

(4) CEDECO School at Kempesi

This institution is engaged in training villagers in improved agricultural practices and handicrafts. Staff at this school had planted maize hybrids from the tropical programs of the Pioneer and Cargill seed corn companies the preceeding November. These hybrids, Pioneer x 302, Pioneer x 304 and a Cargill hybrid, had been severely damaged by drought.

(5) Louvanium University

(6) Chinese Agricultural Mission Project, Thysville.

These six sites will be used for maize varietal trials and for fertilizer response trials. Staff and facilities at all sites seem adequate for the required operations.

Suggested modification of maize trials:

Dr. Eberhart, maize breeder of the East African maize improvement program, in the report of his 1968 tour of the Congo suggested that Nigerian maize selections be compared with improved Congolese selection in trials in the lower Congo. Unfortunately it appears that seed of only one Congolese maize synthetic G.P.S.2 will be available for the February trials.

Dr. Craig proposed the replacement of these unavailable Congolese entries with two entries, NS5 and 094, from Nigeria, NS5 and 094 are maize synthetics that have yielded more than 5000 lbs. of grain per acre in Nigeria.

The entries in the February 1969 trials will be:

1. G.P.S. 2
2. Ibadan Composite A
3. NS 5
4. 094
5. Local farmers maize

The Congolese selections, G.P.S. 4 and GAN, should be included in future trials as soon as seed is available.

A trial to determine effects of various levels of application of commercial fertilizers on the yield of G.P.S. 2 has been proposed for each maize varietal trial site. Discussions with agronomists and soil chemists revealed wide differences of opinion on the pH of soils in this area of the lower Congo. Estimates ranged from strongly acid to neutral. Dr. Craig suggested that a complete soil test be carried out on each trial site. Information from these tests may be of value in explaining yield responses or lack of response to fertilizers. In addition Dr. Craig suggested that the soils specialist from the OAU/STRC Major Cereals Improvement Project in Nigeria should visit this area to assist in formulation of recommendations for fertilizers.

Diseases:

Maize rust and maize leaf blight were observed in all maize plots studied but damage caused by these diseases was very small. The reason for this low incidence is not known but the low rainfall in December characteristic of this area is a possible cause. Both blight and rust require frequent intervals of highly humid conditions for severe outbreaks. If so, it is probable that these diseases will cause significant losses in wetter seasons.

In addition to blight and rust some maize plants at Gimbi and Kimpesi exhibited symptoms characteristic of downy mildew.

Marketing:

As noted by Dr. Eberhart in his Congo tour report a dependable market for maize must be established if the proposed maize production scheme is to be effective.

Observations by Dr. Craig indicate that the major use of maize produced in the lower Congo will be for livestock feed. The details of the price paid to farmers, locationof buying centers and the amount of maize required by the market should be worked out before encouraging farmers to embark on increased maize production.

Dr. Craig visited Ghana from June 22 to June 26, 1969 to observe the maize improvement program being conducted there. During the course of this tour, he visited Accra, Jumasi, Ejura and Atebubu and discussed maize production problems with members of the Crops Research Institute and USAID specialists.

Maize Breeding:

The maize breeding program for Ghana is conducted at the Crops Research Institute in Kumasi by Mr. Akposoe. This program is primarily concerned with the development of maize composites from which improved synthetics will be selected for release to farmers.

Three maize composites have been produced and will be subjected to recurrent selection for yield and other desirable characteristics. In addition to his work with composites Mr. Akposoe is conducting evaluation trials of maize introductions to identify maize varieties suitable for release to growers or for use in his breeding program. Promising varieties are being converted to the high lysine grain type to improve their feeding value.

Mr. Akposoe stated that the breeding program must take into account the significant differences in length of growing seasons among maize growing areas in Ghana. He felt that the situation necessitated the development of both long and short season maize types. In addition to yield and adaptability Mr. Akposoe believes that improvement in lodging resistance should be given a high priority due to the large losses in yield due to lodging.

Seed Production:

Seed production of recommended crop varieties including maize is the responsibility of the agricultural extension division of the Ministry of Agriculture. Dr. Boling the USAID seed specialist informed Dr. Craig that the maize variety, Diacol V153 had been recommended by the Ministry of Agriculture and was being multiplied. A large quantity of seed was expected to be available for distribution to farmers after harvest in August, 1969.

Commercial Farms:

Commercial Farms Ltd., a large scale maize and rice farm jointly owned by the Government of Ghana and the Standard Bank of West Africa was started at Atebubu in 1969. Modern agricultural methods are being used with commercial fertilizers and chemical weed control.

Three hundred and seventy acres of Diacol V153 had been planted on this farm. Mr. Berridge, the farm Manager, had noted in earlier correspondence with Dr. Craig the quality of Diacol V153 seed he had been able to secure was very poor as a result the plant populations per acre were below optimum. In other aspects the plantings looked very good.

Diseases:

The incidence of maize rust (*Puccinia polysora*) and maize leaf blight (*Helminthosporium maydis*) was very low in maize fields at Kumasi, Ejura and Atebubu. Mr. Akposoe informed Dr. Craig that these diseases were not prevalent in these areas in central Ghana but caused more damage to maize in Southern Ghana.

A high incidence of a leaf spotting condition resembling the disease zonate leaf spot (*Gloeocercospora sorghi*) was observed in the plantings of Diacol V153 at Atebubu. Disease samples were collected and given to the plant pathologist of the Crops Research Institute for study. If Diacol V153 is to be widely grown in Ghana in the future this disease may present a serious problem.

Discussion:

The possibilities of improvement in maize production in Ghana appear good. Maize was in short supply at the time of Dr. Craig's visit and maize was selling in Accra for 15 cedis (one Nigerian pound = 2.8 cedis) per hundred weight. This price was expected to fall when maize from the early season is harvested however the proposed government support price of 4 cedis per hundred weight should provide encouraging returns to farmers using recommended varieties and agronomic practices.

Under these conditions it should be possible to persuade farmers to accept improved maize varieties and adopt recommended agronomic practices including the use of commercial fertilizer. Care should be taken that supplies of seed and fertilizer and facilities for marketing and storage are available to growers if the present situation is to be exploited to the best advantage.

The maize breeding program at Crops Research Institute appears to be well conceived. The composites presently in this program would be improved as breeding material by increasing their genetic variability. This could be done by mixing maize composites developed in Nigeria with the Ghanian composites.

Some differences of opinion were expressed by maize workers in Ghana on the importance of color and grain type in the acceptability of maize for human consumption. Most of the maize grown in Ghana is used for human consumption. Information on which factors, if any, determine acceptability by consumers should be secured and used in the development of improved maize synthetics.

On a basis of limited observations the liaison between agricultural research and agricultural extension should be improved. A cooperative program involving these two organizations would expedite the identification and solution of problems involved in increasing maize productinn in Ghana.

Training:

For the second year Dr. Webster taught plant breeding the second term to the part three students of the College of Agriculture, Ahmadu Bello University. Of the 18 students in the class, two were sent to the U.S.A. for graduate study and four were assigned positions as graduate-in-training. After one year of on-the-job training these boys could become eligible for graduate study.

Mr. S. K. Manzo, a promising third year student in agriculture at Ahmadu Bello University, spent three months during the 1969 growing season working in the cereals pathology program. It is hoped that, after completion of his B.Sc. course this summer, the Major Cereals Project will be able to send him to the United States for 12 to 18 months of course work in plant pathology and related subjects. He would then return to Ahmadu Bello University to complete his thesis research in some aspect of cereals pathology for the M.Sc. degree from Ahmadu Bello University.

A graduate from the Botany Department of the University began serving as a graduate-in-training with the Cereals project in August. After a year, if he qualifies, he will be sent away for a year's academic training and return to do his research for his M.Sc. and receive his degree at Ahmadu Bello University. His schooling will be financed from a Rockefeller grant.

A similar arrangement for academic training may be worked out for a member of staff in the soil section who would return to do his research for a Ph.D. degree under Dr. Stockinger's direction.

One research officer of the Nigerian Federal Department of Agriculture has been assigned to Dr. J. Craig for training in the disease control aspects of maize improvement. A second research officer is receiving training in recurrent selection techniques for yield improvement in maize composites.

Regional Sorghum trials:

Regional sorghum trials were started in West Africa in 1966. Based on the results obtained in 1967 it was decided to divide the region and have two trials in 1968, one for the Guinea Savanna and the second for the dryer Sudan Savanna. Seed was sent to 11 countries: Senegal, Mali, Gambi, Upper Volta, Niger, Dahomey, Nigeria, Camerouns, Chad, Ghana and Uganda. Data were returned from 9 countries.

The Guinea Savanna trial in 1968 included 9 entries and usually a local check variety. The yield data from the six trials are given in Table 1. All entries, except Toko Bessenou from Dahomey, originated from Mr. Andrew's project at Zaria, Nigeria. The varieties and the one hybrid, 5069 x 5764 are considered genetically to be 3-dwarf types, the same as most grain sorghum hybrids grown in the U.S.A. They are taller, because they head in about 120 days from planting or about twice the period required for U.S.A. hybrids. The yield data presented in the table illustrates the importance of local adaptation. Sefa, Senegal and Farako-Ba, Upper Volta are in the Guinea Savanna zone but yields of these long season varieties were depressed by below average rainfall. On the other hand the yields from Guetale, Camerouns, in the Sudan Savanna, were relatively better due to favorable rainfall. Toko Bessenou heads in about 140 days and is adapted only in the southern Guinea Savanna. The varieties developed at Zaria have a rather limited range of adaptation within Nigeria, fitting a belt not more than 100 miles wide across the country. It is unlikely that a single variety can be found which will be widely adaptated in this zone.

Table 1. Yields reported from the Guinea Savanna Regional Sorghum Trial, 1968. Kilograms per hectare.

Entry	Country: Cameroun	Ghana		Nigeria	Senegal	Upper Volta
	Location: Guetale	Nyankpala	Yendi	Samaru	Sefa	Farako-Ba
Short Kaura 5912	1625	1168	934	1496	561	262
WX-60	375	1201	577	2254	1361	156
Hybrid 5069 x 5764	925	1328	1044	3352	955	293
5764	250	633	632	1313	383	131
Sk-MDW 2347	4175	1331	632	1754	472	462
CKB (SKMDW) 2083	1225	1622	549	1885	827	306
GSK - 2142	250	1201	605	1095	572	250
GSK DD Shallu 2921	625	470	274	1410	755	93
Toko-Bessenou	3850	--	--	146	83	331
Local	--	1071	112	--	783	128

The situation is somewhat different in the Sudan Savanna. NK-300, a commercially grown hybrid from the U.S.A., is the top yielding variety in most trials (Table 2). Unfortunately the grain of the hybrid is brown in color and would not be eaten by most of the people in the area. This characteristic may add to its good yield performance since the grain is relatively unpalatable to birds. The hybrids from India; CK-60 x IS 84-2, 172 x IS 84-2, 3675 x IS 3691 and 172 x IS 84-1 have good grain quality for human food and yield quite well. They are, however, susceptible to Striga, a parasitic weed, which would limit their production in west Africa.

Table 2. Yields reported from the Sudan Savanna Regional Sorghum Trial, 1968 Kilograms per hectare.

	Country									
	Cameroun	Dahomey	Nigeria		Senegal		Upper Volta		Mali	Niger
	Location									
Entry	Guetale	Niaouli	Samaru	Kano	Bambey	Richard Toll	Saria	Farako-Ba	Bamako	Tarna
Ck-60 x IS84-2	2750	977	2317	1272	3551	2580	1225	1687	2800	4089
172 x IS84-2	3425	885	3273	899	2315	2900	885	1137	2820	3322
3675 x IS3691	575	911	2155	1324	2418	1772	738	987	2570	3344
172 x IS84-1	2250	1016	3497	1035	2849	2740	888	1178	3080	4038
Hegari	500	638	1830	847	2982	2380	345	306	830	1647
Meloland	137	807	1118	865	2284	2240	245	243	1320	1690
NK-300	5350	1953	4370	1797	4226	4140	1998	1968	3400	3940
E 57	1875	547	3558	1425	1818	1980	1503	962	1920	2392
F 65	2250	990	2175	981	1373	780	420	496	1960	1822
E 61	2250	1016	2928	1297	1542	1140	718	818	2130	1952
Local	3500	--	--	--	2826	1840	583	1581	--	2547

An observation nursery of 43 items was first planted in the Sudan Savanna Zone in 1968. Included were several exotic grain type hybrids and a number of lines selected from the Asian Nursery. The Asian Nursery grown at several locations around the world is sponsored by the sorghum program of the Rockefeller Foundation in India. The purpose of the observation nursery is to first identify potentially good varieties which can later be put into the regional yield trials. It also provides the sorghum breeders with selected material which may be useful as parental stock in their breeding programs. One variety, IS 9290 added to the 1969 yield nursery is being increased in Nigeria and for possible recommendation and release.

Although the potential value of sorghum hybrids has been demonstrated, seed production has its problems in the tropics. Cytoplasmic male -sterile A lines are extremely susceptible to ergot infection when grown during the wet season especially if pollination by a fertile B line is not effected immediately after the florets open. This means that the "nicking" of the two lines must be perfect. Seed set is not as good in the tropics as in the temperate zones due probably to the low wind movement during the wet season. Sufficient isolation for a seed field in an area where sorghum is the predominant crop is almost impossible to find. Some of the problems can be solved by off-season plantings under irrigation during the dry season. Such seed production fields can not be located in the Sudan Savanna since soil temperatures at this season of the year are too low for normal growth. A possible solution, and some success has been achieved to date, is to plant seed production fields during the dry season under irrigation in the Guinea Savanna zone where temperatures are more favorable for growth.

Seed for the 1969 sorghum nurseries was distributed to the same 11 countries. A major problem in conducting regional nurseries is the distribution of seed. For example, seed sent in March from the Gambia was received in Nigeria the following July. We have found the U. S. Embassies in the cooperating countries most helpful in seed distribution. We are most grateful for this assistance.

Millet Trials:

There is probably a larger acreage planted to millet (Pennisetum) than to sorghum in the Sudan Savanna zone of west Africa. This is a very important food crop, since one type (gero)

planted in the southern part of the area in May is harvested in August and provides a source of food during the period before sorghum is harvested in November or December. In the areas further north millet is grown as a sole crop and provides the only staple food for the people. Little breeding work has been done with this crop in west Africa and the purpose of the first regional trial was to give an opportunity for the few millet breeders to grow the best material available and to select germ plasm for their breeding programs.

The 1969 nursery included 2 varieties from Niger, 1 from Ghana, 5 from Mali, 1 from Nigeria and 2 from Senegal. The varieties from Nigeria, Senegal and Niger were similar, those from Mali were late and those from Ghana were earlier and similar to the millet being grown in Uganda. Dr. Bhardwaj, millet breeder at Kano, Nigeria made available a collection of his new dwarf varieties to Maradi, Niger; Bambey, Senegal and to Zaria, Nigeria. As expected, most of these new untested varieties performed poorly but a few had enough potential for further testing.

1968 West African Uniform Maize Trials

The West African uniform maize trials were started in 1967 to test promising maize selections at different sites in West Africa. The results of these trials serve to identify maize entries of interest to maize improvement programs in West Africa and should increase the exchange of seed of desirable maize types among maize breeders in this area.

The 1968 trials were conducted at Sefa, Senegal, Saria, Upper Volta, Bouake, Ivory Coast and Ibadan, Mokwa and Samaru in Nigeria. Observations were made of dates of anthesis, diseases, plant populations, lodging, yields and growing conditions. Reports of trial results were prepared by trial supervisors at each site and submitted to the OAU/STRC major cereals project at Ibadan. These reports have been compiled and the yield data are presented in Tables 3 and 4.

Discussion

Yields at Samaru, Nigeria were best of all trial sites. Certain trial entries were not tested at Samaru because of lack of seed but of the 8 entries tested all except H.J., an Ivory Coast entry, yielded higher at Samaru than at any other site.

Table 3. Yields of 1967 West African Uniform Maize Trial Entries at 6 Sites.

Entry	Origin	Sites and yields lbs./acre						
		Ina Dahomey[a]	Saria Upper Volta[a]	Sefa Senegal[a]	Ibadan Nigeria[a]	Mokwa Nigeria	Samaru Nigeria	Mean
Composite D'Ina	Dahomey	2715 A	2300 AB	2536 A	3448 A	3330	4855	3197
Massayomba	Upper Volta	2800 A	2320 A	2341 A	3250 AB	3090	4420	3037
Aldiobla blanc	" "	2460 AB	2360 A	2581 A	2681 CD	3530	4755	3061
Darsalam	" "	2100 BC	2040 AB	2314 A	2442 D	2280	3712	2481
Flint de Saria	" "	1550 D	1520 C	2358 A	1039 F	1010	3037	1752
ZM 10	Senegal	1810 CD	1440 C	2848 A	1460 E	2250	3628	2239
NS 1	Nigeria	2260 B	1495 C	2127 A	3052 ABC	4150	3748	2805
NS 4	Nigeria	1850 CD	1540 C	3097 A	3003 BC	2480	3594	2594
NS 5	"	2310 B	1800 BC	2492 A	3127 AB	2740	4855	2887
Mean		2206	1868	2522	2611	2762	4067	
L.S.D. 5%		--	--	--	--	636	717	

a Yields at a given site with an alphabetical letter in common are not significantly different at the 5% level. Yields with no alphabetical letter in common are significantly different at the 5% level.

Table 4. Yields of 1968 West African uniform maize trial entries at 6 sites.

Entry	Origin	Sites and yields lbs./acre						
		Saria Upper Volta a/	Sefa Senegal b/	Ibadan Nigeria b/	Mokwa Nigeria	Samaru Nigeria	Bouake Ivory Coast	Mean
Composite d'Ina	Dahomey	1680	1007 E	2178 CD	2540	4586	3032	2504
Aldiobla blanc	Upper Volta	1536	1166 DE	1859 E	-x	-x	3122	1921
Massayomba	" "	1821	1588 BC	2265 C	-x	-x	3211	2221
Darsalam	" "	719	1265 CDE	1510 F	1840	-x	2943	1655
ZM 10	Senegal	1908	1763 AB	1365 F	1790	4247	2141	2202
BDS	"	2335	2156 A	1452 F	1960	5082	-x	2597
NS 1	Nigeria	1724	909 E	2381 C	3340	5179	deleted xx	2707
NS 4	"	1251	1918 AB	2004 DE	2590	5639	deleted xx	2680
NS 5	"	2802	1701 B	2730 B	3130	5602	deleted xx	3193
HJ	Ivory Coast	1289	1531 BCD	3020 A	2310	3836	4727	2785
H 59	" "	1141	1134 E	2294 C	1920	4780	x-	2254
Mean		1655	1467	2096	2380	4869	3196	
L.S.D. 5%			--	--	644	1059	624	

a/ Yields of NS5 and BDS are not significantly different. Yield NS5 significantly higher than entries other than BDS.

b/ Yields with an alphabetical letter in common are not significantly different at the 5% level. Yields with no alphabetical letter in common are significantly different at the 5% level.

x - = not present in trial

xx deleted = Observations deleted from trial because of extremely poor stands.

Low stand counts of NS1, NS4 and NS5 reduced yields of these entries at Bouaké, Ivory Coast; yields of most other entries at this site were moderately good. A severe drought reduced maize yields at Sefa, Senegal for the second year in succession.

The low yields and high incidence of barreness among maize entries at Saria, Upper Volta probably were caused by insufficient fertilizer, particularly nitrogen, for the high plant populations used at this site. Yields at Mokwa, Nigeria were reduced by millipede damage to seedlings which required replanting and produced a trial stand count approximately 20% below that recommended for the area.

Yields at Ibadan, Nigeria were adversely affected by abnormally high rainfall, heavy lodging and severe attacks of maize rust. Ibadan was the only site at which maize rust appeared to be an important factor in reducing yields.

LOCAL ACTIVITIES

Maize Improvement in Nigeria
O. J. Webster

The maize improvement program in Nigeria is conducted at Zaria and Mokwa in the north, and at the Federal and Western State Agricultural Research Stations in the west at Ibadan. The program is coordinated by the Federal Department of Agriculture. A workers' conference is held each year in January or February to discuss the results of the previous year's work and to plan for the coming season.

Zaria is the most northerly station in Nigeria where maize improvement work is in progress. It is situated 11°7' north latitude. The mean rainfall for the year is 43.3 inches (1102mm) falling within the mean wet season of May 2 to September 20. This is a favorable growing season for the crop which, when planted in late May or early June, matures at the end of the rains. Grain moisture by mid-to-late-October is reduced to less than 12%.

The ecological zone, represented by Zaria, extending across Nigeria and West Africa could become a major maize production area when adapted varieties are developed and problems of management solved.

The maize breeding work at Zaria was started in 1964. Prior to that time the program was confined to growing the National Uniform Trial. The major objectives of the present program are to develop productive varieties, which will:

1. mature in 100-110 days,
2. resist root lodging so that the plants will remain erect until the moisture is reduced to less than 12% moisture,
3. have long enough ear shanks so that the ears will drop over at maturity to shed water from late rains,
4. have a tight tip husk to prevent bird damage and help resist insect infestation.

Much of the maize in the north is grown near the village and is harvested when the grain is well developed and is eaten green. The breeding program is designed to develop varieties for dry grain production to be stored for human and possibly livestock food. At the present there does not seem to be any widespread preference in the north as to the type of dry grain desired. All grain types can be found in the traditional varieties, ranging in color from white, to purple, and to yellow, and in texture from flour to flint. The established composites from which varieties will be selected are genetically broad enough to develop the type of grain required.

Rust (P. polysora and sorghi) a prevalent disease of maize in west Africa, develops too late in the season to be a problem at Samaru.

Stem borers are not as serious an insect pest on maize as on sorghums at Samaru.

There is some disagreement as to the relative susceptibility of maize and sorghum to Striga. Both crops will fail when planted on badly infested soil. Striga may be one of the factors for preventing the expansion of maize production in northern Nigeria but the chief cause is probably the sensitivity of this crop to an imbalance in soil fertility. Management problems will be discussed in other papers given at the Conference.

The initial breeding program was built around some 38 introductions from Colombia supplied by Dr. Lindsey in 1964, maize breeder at the University of Ibadan. These introductions were tested as various hybrid combinations. Based on the results of these trials three Composites were formulated:

Composite 1: Mexico-5
C-8 (USA 342 x Diacol V 206)-4# x Diacol V 254)#
C-18 Composite 3 Amarillo Centro America (Cuba 40-Hawaii 5-San Luis Potosi 104)-2#
C-31 (Ven. 1-6# x Eto)-4#
Biu Yellow

Composite 2: C-5 (Yotoco x Diacol V 351)-3#
C-8 ((USA 342 x Diacol V206)-4# x Diacol V254)#
C-10 ((Cub. 325 x USA 342)-4# x Diacol V 254)#
C-12 ((Yotoco x Diacol V 351)-2# x Diacol V 254)#
C-16 Compuesto Caribe Amarillo (Cuba-Puerto Rico)-2#
C-18 Composite 3 Amarillo Centro America (Cuba 40-Hawaii 5-San Luis Potosi 104)-2#
C-30 (D.V. 101 x D.V. 351)-4#
C-31 (Ven. 1-6# x Eto)-4#
C-33 D.V. 351
Biu Yellow

Composite 3: C-8 ((USA 342 x Diacol V 206)-4# x Diacol V 254)#
C-18 Composite 3 Amarillo Centro America (Cuba 40-Hawaii 5-San Luis Potosi 104)-2#
C-25 (Mez. 9 Lineas Blancas x Mez. 5 variedades Blanca)-3#
Biu Yellow

Biu Yellow is a composite from a collection of USA Corn Belt dents made by Harold Royer, agricultural missionary at Biu, Nigeria. This variety in hybrid combination with the Colombian introductionts gives our most productive maize.

Various breeding schemes are being used to improve the three composites; namely, mass selection, ear to row, and full-sib family selection. The average yield of an ear to row test of Composite 3 planted in a 11 x 11 lattice design in 1968 was 7,000 lbs/ac (7840 kg/ha). We are not only encouraged by the yield potential of this composite but also by its resistance to root lodging.

Franz de Wolff has been working with these three Composites at Mokwa, but they are not so well adapted.

Within each composite we have added high-lysine and brachytic lines. These lines are detasseled when grown with the Composite during the wet season, and harvested ears are planted ear to row in the irrigated nursery, and selfed or sibbed. In this manner it is possible to select opaque-2 seed for planting

each wet season and F_2 segregates for height from the brachytic material are available for selection. We have no plans to develop brachytic varieties, but the stocks are being used to develop adapted varieties with reasonable ear height and stalk strength.

The Institute for Agricultural Research at Zaria is cooperating in the development of the broad base composites formulated at our maize conference held at Ibadan in February 1968, and reported at the present conference by Dr. Craig and published in Agronomic Tropicale, January 1969 by J. LeConte. We are developing at Zaria one composite, A. This particular composite includes our own composites 1, 2, and 3. By the end of next dry season (May 1970) Composite A will have been cycled four times, with only limited selection at each cycle. The first selection will be by straight mass selection (1970), according to the scheme suggested by Gardner.

Maize Improvement at Samaru
O. J. Webster

Maize production is on the increase in some parts of northern Nigeria. Greater effort is planned to promote this crop in the areas with soils and climate similar to those of Samaru. Since the improvement project was started at this location in 1965, average yields each year have exceeded 4000 pounds per acre with maximum yields of over 7000 pounds. Farmers in the area should be able to duplicate these yields by planting seed of the improved varieties being developed at Samaru and by following recommended practices of good husbandry.

The experimental fields at Samaru on which the maize is planted have been in continuous cultivation for over 15 years and very little organic matter has been returned to the soil in form of crop residues. The fields planted to sorghum and groundnuts receive, as a rule, a blanket application of 150 pounds per acre of single super phosphate each year and 200 pounds are applied to the fields to be planted to maize. Adequate phosphate is the first essential for crop production in these soils followed by an application of nitrogen at the time of planting or emergence of the crop and a second application about six weeks later. A total of 90 pounds per acre of nitrogen has been the standard rate for maize. Since this amount is not enough to produce a 6000 pounds per acre grain crop even with 100% uptake, the rate must be increased to maintain continued high production and give further increases in yield. In the more sandy soils in northern Nigeria potash is a limiting factor in maize production.

Based on the results of limited date of planting trials, maize yields are stable from plantings made anytime up to mid-June. Yields are reduced when plantings are delayed after this date. The experimental fields are kept free from weeds by frequent hand weeding. Herbicides have given good weed control in maize at Samaru and they will be used on most of the project in 1970.

Seed and fertilizer were distributed in 1969 to seven selected farmers in the Samaru area to be planted and cared for according to recommendation. This was a new experience for these farmers and those who followed instructions had a good crop. Farmers who are not accustom to using fertilizer, plant their seed in hills spaced at three feet or further apart. One farmer followed the recommendation of having plants spaced a foot apart in the row. Two of the fields were badly infested with Striga and the crop was a failure. This type of trial will be expanded to several additional farms in 1970 as a part of the extension service's educational program.

The Major Cereal Project cooperates with the Federal Department of Agriculture in planning and conducting the National Zonal Trials which were grown at about 16 sites in the country in 1969. Recommendations are based on the performance of the varieties in these trials. A summary of the yields of the varieties included in these trials at Samaru since 1964 is given in Table 5. The poorest yields were reported in 1964 when maize was planted on a field where the water table rose to within two feet of the surface in August. Maize must be planted on well drained soils for high yields. The average annual precipitation at Samaru is 44 inches. This is more than a maize crop requires and the rainfall is adequate even in the driest years. Generally the rains taper off towards the last of September which is ideal for drying the grain in the field. It seems a reasonable assumption that by using improved varieties and good husbandry, maize could become a major crop in areas in west Africa with soils and eliminate similar to those at Samaru.

The Nigerian Maize Workers Conference held in Ibadan in February 1968 was also attended by Dr. Eberhart, maize geneticist from Kitale, Kenya and J. Le Conte, millet maize-sorghum specialist from IRAT. Three broad based Composites were formulated to be used as the basic materials for future maize improvement in Nigeria and other west African countries. Composite A has been cycled four times at Ibadan and Mokwa, and three times at Samaru, while Composites B and C have been cycled four times at Ibadan. Selection will begin in these Composites in 1970 using various schemes, depending upon the facilities available at a location.

Table 5. Summary of yield of maize varieties included in the Federal Zonal Trial. Samaru, 1964-1969. (lbs. per acre)

Entry	1964	1965	1966	1967	1968	1969	Av. 1965-69	Av. 1968-69
H 503	3071	5653	3920	4602	4635	5974	4957	5305
Diacol V-153	2882	5152	4225	5202	4730	5216	4905	4973
H-507	2684	5174	3237	4785	3382	5650	4445	4516
NS-1	2190	4859	3910	5029	4762	5505	4813	5133
NS-5	2294	5222	3116	5309	5316	5758	4944	5537
Mexico-5	--	5305	4293	4692	4658	5650	4920	5154
E A F R O 231	--	4208	4114	5031	3387	5577	4463	4482
Composite A	--	--	--	--	5784	6227	--	6006
Composite A x B	--	--	--	--	5997	6570	--	6284
Bulk 3	--	--	--	--	5748	6426	--	6087
Dahomian Composite	--	--	--	--	5012	5379	--	5196

Composite A as formulated at Samaru included 30 lines. These lines were planted in single plots and replicated three times. The tassels were removed before pollen shed and pollination was effected from border rows planted to a mixture of seed of the 30 items. The yield level of the 30 components should equalize with continued synthesis. Yields taken at Samaru in the third cycle ranged between 5271 to 7042 lbs. per acre. Only 3 of the components gave yields of less than 6000 pounds. Yield differences were not statistically significant. This trial illustrates the yield potential of this Composite and a significant advance may be expected by selecting within it.

Selection has continued in Samaru Composites 1, 2, 3 and Ibadan Bulk 2, (Table 6). Yield differences are small and are not statistically significant but the trends are in the direction hoped for. Yields have increased by continued selection. The composite formed at Mokwa by blending seed of the three Samaru Composites followed by selection gave a yield of 6516 lbs. per acre which exceeded the yield of the parent composites.

The selection of the components of the Samaru Composites was based largely upon the combining ability of numerous introduced varieties, primarily those from Colombia. Included in each of the Samaru Composites is a variety known as Biu Yellow which was selected in Nigeria from a Composite made up of numerous U.S.A. Corn Belt hybrids. This variety has the highest general combining ability of all those tested at Samaru (Table 7).

Eleven varieties were topcrossed to Biu Yellow in 1968 and the yields of the topcrosses grown in 1969 (Table 8) ranged from 5673 to 7118 lbs. per acre for C-4 x Biu Yellow and A-154 x Biu Yellow, respectively. The yields of the 12 parent varieties ranged from 3925 lbs. per acre for EAFRO 269 to 5851 lbs. for Biu Yellow.

An attempt is being made to improve Biu Yellow by S_1 testing. In 1969, 121 S_1s were grown at two locations at Samaru. Remnant seed of the top yielding 19 lines was sent to Ibadan for intercrossing in all combinations. These lines grew very poorly at Ibadan but if the crosses are successful, seed will be planted soon after harvested and the progeny plants selfed. The selfed seed will be returned to Samaru for planting in a yield trial in June 1970, thus starting the second cycle of selection. Maize grows quite well at Samaru in the irrigated nursery during the dry season but growth is not as fast as at Ibadan and only one crop can be produced.

Table 6. Yields of hybrids and parental varieties grown at Samaru and Shika, 1969.

Entry	Samaru		Shika		Average	
	lbs/ac	Rank	lbs/ac	Rank	lbs/ac	kg/ha
A-154 x BY	7079	3	7157	1	7118	7972
EAFRO 272 x BY	6852	4	6871	2	6912	7741
C-5 x BY	7439	1	6334	3	6887	7703
C-33 x BY	7278	2	5744	8	6511	7292
C-18 x BY	6706	5	6044	5	6375	7140
A-49 x BY	6588	7	6211	4	6320	7168
V-56 x BY	6643	6	5599	11	6121	6856
EAFRO 269 x BY	6098	11	5860	6	5879	6697
C-12 x BY	6171	9	5754	7	5863	6678
Biu Yellow (BY)	5999	12	5714	9	5857	7318
V-56	6389	8	5200	14	5795	6490
C-10 x BY	5826	13	5608	10	5717	6403
C-4 x BY	6119	10	5227	13	5673	6354
C-18	5028	19	5291	12	5155	5779
EAFRO 272	5336	15	4311	17	4844	5403
C-6	4955	20	4446	16	4701	5265
C-4	5109	17	3959	20	4534	5078
A-154	5218	16	3812	21	4515	5057
C-10	4592	21	4156	19	4374	4799
C-5	4483	22	4183	18	4333	4853
C-33	5100	18	3213	23	4157	4656
EAFRO 269	4084	23	3766	22	3925	4396

Table 7. Average yields of hybrids with common parents and yields of parents, Samaru, 1967, 1968, and 1969. (lbs. per acre)

Hybrid with line	1967 No. of hybrids	1967 Av. yield	1967 rank	1968 No. of hybrids	1968 Av. yield	1968 rank	1969 No. of hybrids	1969 Av. yield	1969 rank
C-4							4	5004	13
C-8	14	5329	5	11	5895	11	8	6133	4
C-10	11	5343	4	6	5996	5	12	6011	6
C-12	7	5164	10	4	6115	3	6	5844	9
C-16	10	5231	8	7	5551	13	-	--	-
C-18	11	5487	3	10	5835	10	4	6053	5
C-31	10	5253	7	9	5849	9	-	--	-
C-33	8	5256	6	8	5993	6	9	6149	3
A-154	15	5180	9	11	5657	12	9	5856	7
A-156	7	5050	12	12	5833	11	6	5412	12
A-195	6	5081	11	7	5908	7	-	--	-
A-196	6	4721	14	8	6078	4	6	6289	2
A-49(Tsolo)	9	5517	2	8	6148	2	13	5853	8
BY	9	5833	1	9	6256	1	13	6544	1
NS-1	4	5050	13	-	--	-	-	--	-
EAAFRO 269							7	5808	10
EAAFRO 272							7	5615	11
				Parents					
C-4								3703	16
C-8		4220	9		4265	10		4919	11
C-10		4992	3		5318	3		6189	2
C-12		4184	10		3830	12		4719	13
C-16		3948	12		4574	8		5100	10
C-18		4372	7		4265	11		5826	5
C-31		3231	13		3430	13		--	-
C-33		2705	14		2723	14		4919	12
A-154		5037	2		4610	7		4628	14
A-156		4093	11		5118	4		5627	6
A195		4828	5		--	-		--	-
A-196		4674	6		--	-		5572	7
A-49 (Tsolo)		5425	1		4338	9		5372	8
BY		4302	8		4919	5		5844	4
NS-1		4964	4		5790	1		5173	9
Mexico-5		--	-		5735	2		6225	1
EAAFRO 269		--	-		--	-		6062	3
EAAFRO 272		--	-		--	-		3866	15

Table 8. Yield and other agronomic data from Composites and Intercrosses, Samaru 1969, Planted May 25.

Entry	Source	Av. days to Tassel	Av. days to silk	Av. height ear	Av. height plant	Stand harvest	Yield lb/ac	Yield kg/ha
		no	no	cm	cm	pls/ac		
Composite I	1967	58	60	115	270	14157	5944	6657
Composite I	1968	57	59	120	270	13559	5909	6618
Composite I	68/69	56	59	115	270	15064	6071	6800
Composite II	1967	56	60	110	240	14740	6135	6871
Composite II	1968	56	57	120	270	14520	6271	7023
Composite III	1967	55	60	105	250	14702	5282	5916
Composite III	1968	54	57	105	250	13794	6135	6871
Composite 1-(Mokwa)1/2-3		60	63	135	285	14792	6516	7298
Bulk II	1967	60	64	130	290	14196	5608	6281
Bulk II	1968	57	61	120	285	14742	6044	6769

1/ Reselection of a mixture of Comp. 1-2-3 made at Mokwa

LSD .05 = NS. CV = 10.7%

Seed of nearly 100 introduced and local varieties are maintained at Samaru. The collection was topcrossed to a local variety known as Bomo Local in 1967. These topcrosses were grown in yield trials in 1968 and 1969. Sixteen of the varieties were selected based on these topcrosses performance and were intercrossed in all combinations. These variety hybrids are to be tested in 1970 and 1971 and the data will probably be used for a M.Sc. thesis for a graduate-in-training.

Productive variety-hybrids have been developed but none have the resistance to root lodging which is desired. Hopefully as the demand for maize in northern Nigeria expands, root lodge resistant varieties will be selected out of the composite program which will equal the best variety-hybrids in yield.

A new seed storage facility was put into operation during the year. The temperatures and humidity are maintained at 40°F and 40% with a fluctuation of less than two degrees and two percent. The viability of maize seed at Samaru cannot be maintained much longer than 18 months when stored without temperature and humidity control.

Maize Program Mokwa, Nigeria
F. de Wolff

Irrigation equipment for a two-acre dry season nursery was provided at Mokwa by the Major Cereals Project. With these facilities it is now possible to grow two or three generations a year for the c ereal breeders at Samaru and at Mokwa.

A new wide-based composite, Mokwa Composite A, has been established, similar to the composite A formed in Ibadan and Samaru. Selection in other material was continued, as were the variety trials, and the experiments with planting dates, intercropping and vegetative propagation.

(a) Breeding and selection:

One hundred sixty-nine full-sib families were tested in yield trials, using a lattice design with two replications, tested at two locations at two dates of planting. By selecting the 19 best performing families the expected progress from selection is nine per cent.

The next cycle of selection is currently being carried out by making a new set of full-sibs, by making all possible combinations between the selfed lines from the 19 selected families. These testcrosses are made in the dry season under irrigation. Each cycle of selection takes only one year.

To improve the efficiency of full-sib family selection, the testcrosses entering the yield trials were first selected from a large number of crosses, using a selection index based on the number of ears per plant, the silking time and the length of the main ear. The data, however, from the yield trials showed no correlation between the number of ears and the length of the main ear of the test crosses and their yields. Apparently both characters, number of ears per plant and length of the main ear, depend primarily on the success of the pollination which is also the reason why grain yield is an unsuitable character to use to select among the test crosses made by hand.

A selection-index calculated in1968, taking into account grain yield, number of ears per plant and time of silking was used as a basis for selection within the Colombian Composite. The first cycle was grown in the late season of 1968, and two more cycles were grown this year. This method of selection is being compared with simple mass selection.

Selections have been made within Samaru Composite II for rapid and slow germination of seed. After three cycles of selection the two groups differed significantly from the original population in the time required for germination, but no differences were found in silking time and yield.

Mass selection was continued within the varieties NS-1, EAFRO 231 and Bulk 3. A backcrossing program is in progress using these varieties and the Colombian Composite and Mokwa Composite A to improve the protein quality by incorporating the opaque gene; and to improve the resistance to lodging by reducing the plant-height by using the brachytic gene.

(b) Varieties:

In the West-African regional variety trial Ghana Composite 3 yielded significantly better than NS-1, 3135 and 2731 lb per acre (3521 and 3067 kg per ha), respectively. In the National Zonal variety trial EAFRO 231, NS-5 and H 503 outyielded significantly NS-1 yielding 3152, 3115, 2989 and 2458 lb per acre (3540, 3357, 3498 and 2760 kg per ha), respectively.

Eleven topcrosses with the variety Biu Yellow made in Samaru were about one week earlier flowering than NS-1 but did not differ significantly in yield. In an experiment testing selections from the Composites I, II and III made in Samaru and Mokwa, the Colombian Composite made by mixing the three Composites followed by mass selection outyielded other entries, producing 3600 lb per acre (4043 kg per ha).

In an experiment testing varieties for silage yields, the highest yield of 7550 lb dry matter per acre (8479 kg per ha), was obtained from a selection of NS-1.

Nine introductions were received from Mexico this year and some showed promising features.

(c) Agronomy

In the date of planting x variety trial, the varieties EAFRO 231 and NS-1 were planted at two-week intervals, starting at the beginning of the rains, and countinuing for two months. The first planting on April 10 was an almost complete failure due to lack of rain. The highest yields were obtained from the second planting, April 25, with yield of 3800 and 3590 lb per acre (4267 and 4032 kg per ha) for EAFRO 231 and NS-1. Plantings made two, four and six weeks after April 25 yielded 7, 22 and 44 percent less, respectively. The interaction between dates of planting and varieties was not significant.

A replicated experiment with intercropping maize and groundnuts showed, as in 1967 and 1968, that intercropping produces higher combined yields. The gains in yield produced in two different fields this year were 5.6 and 17.1 percent as compared to monocropping. In one field there was a positive interaction between nitrogen and intercropping. However maize and groundnuts do not prove to be a very suitable combination because individual plant yields for both crops are greatly reduced by intercropping. Also, the maize benefits little from any nitrogen produced by the groundnuts.

(d) Vegetative propagation

Vegetative propagation keeps plant material growing for an indefinite period of time, which could be of use in a breeding program, and also in conducting genetic studies. Two different methods were employed:

1. Artificial promotion of tillering by removal of the growing point. The tillers are transplanted, and the process repeated.

2. Cutting seedlings in halves, with each half possessing a minimum of one leaf with a dormant leaf axil-bud, and one crown root. The buds develop into new plants, and again the process can be repeated.

It was found, however, that neither method could be continued for an indefinite time under conditions of normal day length, because as the plant material becomes older new developing shoots tend to form flower-buds at a very early stage until they resemble ear shoots, and at that stage they have lost their tillering ability.

Maize is a short day plant. When plants of the variety NS-1 were grown under continuous light, the differentiation of the tassel, which normally becomes visible at about twenty-six days after planting, was not observed until forty-nine days after planting. This means also, that when vegetative propagation is practised under conditions of continuous light, the initiation of flower-buds is suppressed at least for sometime. This is now being practised, using the method of artificial promotion of tillering. After completing six cycles of propagation using the same plant material, it is still possible to initiate tillering before there is any visible differentiation of flower-buds.

Maize Improvement-Ibadan
J. Craig

This program is concerned with improvement of maize production in West Africa. Work is being done on development of maize composites for use in breeding programs in West Africa, identification and utilization of disease resistant maize selections, conducting uniform regional trials and training maize workers in improvement techniques.

Maize Composites

The three maize composites A, B, and C, being developed are in their fourth cycle of synthesis and will be ready for release to breeders for selection under their environmental conditions in 1970. High lysine disease resistant versions of these composites will be available in 1971.

These composites possess good selection possibilities for yield, plant height, maturity time, standability and other agronomic characteristics. In addition the genetic divergence among these composites will improve the probability of heterosis in crosses between selections from different composites.

It is expected that these composites will prove an extremely valuable addition to maize improvement programs throughout west Africa and other tropical areas.

Recent work in the United States has shown that the upright leaf character in maize permits more effective utilization of sunlight in dense plant populations than the normal leaf arrangement. A project to develop upright leaf versions of the Nigerian composites was started in 1969.

S_1 lines were produced from the progeny of plants exhibiting the desired leaf character in an open pollinated population of composite B. The frequency of these plants in the observed population was extremely low. S_1 plants showing the upright leaf character were selfed. S_2 seed from these plants will be bulked to provide the non-recurrent parent in back-crossing programs using composites A, B and C as recurrent parents.

West African Uniform Maize Trials:

These trials were started in 1967 to identify superior maize varieties being grown in West Africa, to determine if zones of adaptation for maize types existed among maize growing areas of West Africa and to improve the exchange of seed and information among the maize improvement programs of African countries.

Trial entries consist of maize varieties and synthetics from west African countries. Seed for trials are distributed to testing sites in the participating countries by the AID-ARS project at Ibadan. Trials are conducted by maize specialists in the various countries and results are sent to Ibadan for compilation and distribution.

The number of countries participating in these trials has increased from 4 in 1967 to 8, Mali, Senega, Upper Volta, Gambia, Ghana, Dahomey, Ivory Coast and Nigeria, in 1969. The 1967 and 1968 trials have served to identify and arouse the interest of participating countries in comparatively high yielding maize entries (Tables 3 and 4).

Trials were damaged by drought in Dahomey and Nigeria in 1967 and severe droughts occurred at Sefa, Senegal in both 1967 and 1968. As shown in Tables 3 and 4 the highest yields and presumably the best growing conditions occurred at Samaru, Nigeria in both 1967 and 1968.

Two years of testing are insufficient to determine zones of adaptation particularly as atypical conditions have occurred at some testing sites during the trial years. However the standard scores of certain trial entries indicate that they differ in their adaptability to different sites. ZM 10 and BDS maize entries developed in Senegal, scored comparatively well at Senegal and badly at Ibadan, Nigeria. NS1, a Nigerian maize entry, scored above the mean at Ibadan and well below it at Senegal. Fortunately the high scores of Composite d'Ina (Dahomey), Massayomba (Upper Volta) and NS5 (Nigeria) at most sites indicate maize varieties developed at one site can be suitable for most of the sites tested to date.

The uniform maize trials are expected to be of value as a means of arousing regional interest in the Nigerian maize composites which will be released in 1970.

Disease Resistance

The most important diseases of maize in west Africa are maize rust (*Puccinia polysora*) and southern maize leaf blight (*Helminthosporium maydis*). These diseases singly or in combination cause severe reduction in the yields of susceptible maize varieties. The only economically practical means of control is the development of disease resistant maize varieties.

The AID-ARS maize program at Ibadan has developed three maize lines possessing hypersensitive resistance to all races of P. polysora found in Nigeria to date. Studies are now underway to determine the relationship among factors controlling resistance in these maize selections. Results at this stage indicate that a single genetic factor controls rust reaction in each line but this factor is not the same in the three inbreds.

If it can be demonstrated that different loci are involved it would be possible to place 2 or possibly 3 factors for resistance in one maize selection. This would decrease the possibility of a break down in resistance due to the appearance of a new biotype of P. polysora.

Research by the AID-ARS maize project on southern maize leaf blight resulted in the development of a maize line possessing a unique and highly effective chlorotic lesion resistance to H. maydis. This blight resistance and the hypersensitive resistance to rust were combined in one maize selection which has been used to transfer rust and leaf blight resistance to the Nigerian maize composites. Maize composites so resistant to blight and rust that they will suffer no losses in yield from these diseases will be available in 1971.

The availability of these composites will eliminate the necessity of selecting for disease resistance and allow breeders to concentrate on selection for yield and other agronomic characters. This should result in a more rapid rate of progress for improvement of these traits.

Maize lines resistant to rust and blight have been sent to breeders in North America, South America, Australia, the Caribbean and East and West Africa. Reports on the reactions of these lines to blight and rust in the above areas were not available at the time of preparation of this paper. If results are favourable these maize selections may prove of value to a large number of maize improvement programs.

A project to develop isogenic maize populations differing only in their resistance to maize rust and maize leaf blight was started in 1969. A rust and blight susceptible variety, 033, is being used as the recurrent parent in back-crossing programs with a rust resistant inbred, a blight resistant inbred and an inbred with combined blight and rust resistance.

After 6 cycles of back-crossing the resulting populations should not differ appreciably from 033 or each other except in their reactions to blight and rust. These maize populations will serve as useful tools in determining losses due to rust and blight, alone or in combination, in different areas of west Africa. In addition they will provide an early warning of any breakdown of these types of resistance by _H. maydis_ or _P. polysora_.

Maize Improvement, Federal Department of Agriculture
Moor Plantation, Ibadan
U.U. Ebong

Maize composites:

The white 'floury' composite C, consisting of a mixture of 25 entries from Central America, South Africa, Kenya and Nigeria was grown through two cycles (3rd and 4th) of synthesis in 1969. At each harvest, all the entries were subjected to 25% selection pressure on the basis of ear weight. It was significant that the differences in the range of silking time was reduced from 15 days in the first cycle to 4 days at the end of the 4th cycle.

The Rb entry is now to be tested for resistance to rust and blight. The resistant plants will be used as pollen parents in the S_1 testing later. The composite is now ready for distribution.

Meanwhile, the comparative study of three selection methods (Mass selection, S_1 selection and selection for ear prolificacy) on a maize synthetic 094, initiated in late 1968 is continuing. This study aims at determining the most efficient method of selection from the composites. The materials have gone through two cycles of selection. The selected materials and the original populations will be compared in yield trials in 1970 early season.

Breeding for short-noded varieties:

Progeny selection in crosses and back-crosses between brachytic varieties R.909 and Dwarf Synthetic II and the high yielding varieties NS-1, NS-4, NS-5, H503, H507 and EAFRO 231 is continuing. The twelve F_1 hybrids obtained in the 1968 early season were back-crossed to the recurrent parents in the early season of 1969. These first backcross progenies were planted out for selfing in the 1969/70 irrigation season. Also, some of the F_1 hybrids were selfed in the early season. Within the resulting segregating F_2 generations, selection will be practised in 1970 early season.

National Zonal Maize Vareity Trials

Table 9 shows the mean grain yields in lbs. per acre at 12 percent moisture of eleven varieties at five sites in the Western State in 1969. A joint analysis of variance was done on the data. Significant interaction between varieties and sites was indicated; for example Composite A which yielded highest (4065 lbs/acre) at Akure gave a very low yield of 1932 lbs/acre at Ipokia. Generally there are no significant differences in yields of varieties H.507, H.503, Diacol-$V_1$53 NS-1 and NS-5. All of the varieties except EAFRO 231 and the Dahomean Composite yielded significantly higher than the local (p=0.05). The yellow flint varieties Composite A and Bulk-3 gave the best grain yields which are significantly higher than the other varieties (p=0.05) except Composite A x B and H.507.

Table 10 shows the varietal mean grain yields in the Northern States. It was found that the interaction between the locations and varieties was highly significant (p=.05); Bulk-3 the highest yielding variety yielded as high as 6426 lbs/acre at Samaru while at Osi the yield came down to 1695 lbs/acre. Here too, the yellow flint varieties Bulk-3, Composite A and NS-1 yielded best with 3507, 3483 and 3417 lbs/acre respectively but were not significantly superior to other varieties except varieties Dahomean Composite, local and Bomo local. The varieties Diacol V-153 and H.503, were superior to EAFRO 231 by 129 and 111 lbs/acre respectively although the differences were not significant.

Table 9. Mean grain yields (lbs per acre) at 12 percent moisture of eleven varieties at five sites in the Western State in 1969.

	SITES					
Varieties	Akure	Ondo	Ilora	Ibadan	Ipokia	Mean
Composite A	4065	3529	2701	2257	1932	2897 A
Bulk-3	4185	3234	2802	2225	1973	2884 A
Composite A x B	3886	3310	2493	1807	1912	2682 AB
H.507	3893	3051	1369	2744	1761	2564 ABC
H.503	3501	3039	2528	2288	1208	2513 BC
Diacol-V-153	3581	2976	2342	2188	1247	2467 BC
NS-1	3310	2784	2290	2302	1498	2437 BCD
NS-5	3108	2579	2467	2360	1445	2392 BCD
EAFRO 231	3303	2708	2312	2146	1172	2328 CDE
Dahomean Comp.	3397	2774	1328	1525	1520	2109 DE
Local	2681	1767	2384	1763	1585	2036 E
Mean	3537	2886	2274	2146	1568	2482
S.E.	150.8	223.4	152.5	150.0	99.8	121.3
C.V.%	8.4	15.1	13.4	14.0	12.7	13.46
L.S.D. at 5%	417.9	619.2	422.6	547.3	276.5	336.1

N.B. Values with identical alphabets are not significantly different at 5% level.

Table 10. Mean grain yields (lbs. per acre) at 12 percent moisture of fourteen varieties at five sites in the Northern States in 1969.

Varieties	SITES Samaru	Daudawa	Karfi	Mokwa	Osi	Mean
Bulk	6426	2736	3941	2736	1695	3507 A
Composite A	6227	2668	3827	2544	2149	3483 A
NS-1	5503	4686	2608	2458	1826	3417 AB
Diacol-V.153	5216	3634	3600	2562	1707	3344 AB
H.503	5974	3257	2892	2989	1517	3326 AB
Comp. A x Comp.B	6570	2475	2636	2744	2004	3286 AB
EAFRO 231	5577	3237	3260	3152	850	3215 AB
Mexico 5	5650	2739	2296	2760	2240	3137 AB
NS-5	5758	3127	2211	3115	1409	3124 AB
C.10 x Biu Yellow	6173	2869	2211	2594	1596	3089 AB
H.507	5650	2611	2240	2842	2058	3080 AB
Dahomean Comp.	5379	2549	2948	2522	882	2856 B
Local	6336	2611	709	2167	1250	2615 B
Bomo local	3664	2764	2410	1863	454	2231 B
Mean	5722	2997	2699	2646	1545	3122
S.E.	66.8	641.8	436.6	212.0	290.3	342.5
C. V. %	8.1	42.8	32.4	15.1	37.7	25.6
L.S.D. at 5%	760	N.S.	1209.9	587.6	804.6	599.7

N.B. 1. Values with identical alphabets are not significantly different at 5% level.
2. N.S. - not significant.

Maize Breeding, Ibadan (Western State)

Henry C. Wiggin

High lysine maize

A white high lysine variety, Western white 1, was released in limited amounts to farmers of the Western State in March. This variety was developed by crossing a homozygous opaque ($o_2/o2$) maize from the United States with V-1, a white dent variety developed in Nigeria. The F_1 was backcrossed to V-1, plants from backcross seed were selfed. S_1 opaque kernels were selected from each segregating ear and entered in an S_1 yield trial. Following harvest and analysis, selected lines were recombined in an isolated plot. Selection intensity was about 35 percent.

Although Western White 1 does not have a particularly good husk cover and is moderately susceptible to rust, it was released to farmers, partly in view of nutritional requirements of the people, and partly to get farmers' responses to a variety whose kernels have an appearance different from that usually grown locally.

Western White 1 is earlier than other varieties grown in the Western State. In view of the slow drying characteristics of this variety and the fact that farmers do not have adequate means of drying maize at the end of the early season, it is now thought that Western White 1 should be recommended for use as green maize in the early season and for dry grain in the late season, when sun drying is possible.

Approximately 3.5 tons (ton = 2240 pounds) were multiplied in the early season for use in the late season, and it is expected that about 25 tons will be available from multiplication plots for planting in the early season 1970.

A second high lysine white opaque variety, (Bulk-3 x V-1o_2), was placed under half-sib mass selection for two cycles in the early and late seasons 1969. The field was planted as a topcross, with three female rows to one male row. A high plant population, 29,040 plants per acre, was used. At harvest, the field was divided into small plots, and selection for ear weight was carried out in the female rows in each plot. Selection intensity was 2.5 percent. Selected seed from the first cycle was used to plant both male and female rows in the second cycle. Results will be assessed in the early season 1970.

Difficulty was experienced with a pale yellow color appearing in the opaque variety, and selection has not been able to eliminate it. Expression appears to be variable in this genetic material. The gene has not been identified, but probably entered from Bulk-3.

A double mutant, fl_2/fl_2; o_2/o_2, is being prepared. The floury-2 x opaque-2 cross was made using a floury-2 source obtained from Dr. Craig and (Bulk-3 x V-lo_2) as the source of opaque-2. The F_1 was crossed with opaque S_1's from second cycle Rbo_2 from Nigerian Composite A, thus being a backcross to opaque-2. From the backcross, a segregation of one translucent : one opaque was expected; however, selection was difficult. A variability in opacity, due perhaps to modifying factors with o_2 or dosage effects of fl_2, resulted in a relatively low percentage of fully opaque kernels being saved. These opaque kernels were planted in the irrigation nursery, and plants will be selfed to obtain homozygous double mutants.

Nigerian Composite A

The third and fourth cycles of recombination of entries in Nigerian Composite A were completed during the year, except for the entry Rbo_2, which has been through three cycles. The entry Rb (rust and blight resistant), was tested for rust resistance, susceptible plants were discarded, and the remainder selfed during the 1968-69 irrigation nursery using space made available by the Federal Department of Agricultural Research and with the assistance of Dr. Craig, USDA.

In the early season 1969, the bulked S_1 seed was planted with the other entries in a randomized blocks design with four replications, as had been used with the first two cycles. Seedling plants of Rb(S_1) were inoculated with Cochliobolus and ten days later, susceptible plants were removed. Areas in the male rows devoted to Rb(S_1) were marked and similarly selected. At flowering, all remaining Rb(S_1) plants in the female rows were detasseled. Data from these plants were not used in the third cycle analyses for date of flowering, ear height and yield.

As there was not room in the irrigation nursery, Rbo_2 could not be selfed at that time. Selfing was done in the early season, with the same selection as used for Rb, plus a selection for homozygous opaque in the S_1 seed. In the fourth cycle of the composite planted in the late season, S_1 plants of Rbo_2 were handled the same as Rb(S_1) in the female rows in the early season. Rbo_2 does not enter the composite as a male.

Selection for ear height was made in the third and fourth cycles of the composite, as was done in the second cycle. All plants bearing an ear in the female rows were measured and height was recorded in inches from the ground to the node bearing the upper ear, in cases where there were two ears. The mean height for each row was calculated, as was the standard deviation of the mean. The statistic, mean + standard deviation, was used for selecting against tall plants, all heights exceeding the statistic for the row being discarded. From the remaining plants, the heaviest 25 ears were selected, giving a selection pressure of slightly less than 25 percent, based on total number of plants in the row before removing the tall ones. For purposes of analysis, height in inches was converted to centimeters.

Yield analyses were based on total ear weight per row, corrected for stand. Data from all four cycles are summarized in Table 11. Maximum, minimum and mean yields per acre are calculated from corrected yields, assuming 20 percent discard for cobs and a moisture percent of 35 in the early season and 22 in the late season. First cycle data do not include yield.

Growing-degree days are calculated in degrees C by adding maximum and minimum temperatures each day from planting to half-silk, dividing by two, and subtracting ten degrees.

Table 11. Statistical data on entries in Nigerian Composite A[1/].

Cycle	Character	Maximum	Minimum	Mean	F value	L.S.D.	Coef.Var. %
	Ear height, cms	141	94	114	10.88++	21.23	10.74
First	Days to half-silk	67	51	58	17.57++	3.46	3.48
	Growing-degree days	1005	708	922	22.62++	3.78	1.82
	Ear height, cms.	172[2/]	130	154	13.68++	11.69	4.37
Second	Days to half-silk	62	58	60	5.44++	1.62	1.54
	Growing-degree days	1029	926	983	4.83++	31.42	0.84
	Yield, lbs./acre	6080	5172	5652	0.71	N.S.	16.88
	Ear height, cms.	123	105	116	1.36	N.S.	7.20
Third	Days to half-silk	64	60	62	1.99	N.S.	2.79
	Growing-degree days	1043	992	1018	2.01	N.S.	1.30
	Yield, lbs./acre	4836	3801	4257	1.16	N.S.	14.36
	Ear height, cms.	124	113	119	1.69	N.S.	5.12
Fourth	Days to half-silk	67	64	65	1.81	N.S.	2.12
	Growing-degree days	1050	999	1024	1.78	N.S.	1.05
	Yield, lbs./acre	4013	3318	3694	0.74	N.S.	15.84

1/ Rb was not included in analyses of the third cycle, because it had been selfed in the irrigation nursery and was in the form of S_1 plants. Rbo_2 was not entered in the third cycle, because it had to be selfed to recover disease resistance and the opaque genotype, and was not included in the analyses for the fourth cycle, because it was in the form of S_1 plants.

2/ Ear heights are not comparable between the first cycle and succeeding ones. Material for the first cycle was planted at nine inches in the row, while the other three cycles were planted at six inches.

++ Significant at 1% level.

The non-significance of all data in the third and fourth cycles and yield in the second cycle is considered to be due to approaching equilibrium. The high yield in the second cycle is probably due to heterosis, although the growing season was especially favorable for maize in the Western State.

It is of interest to examine the ranges found between maximum and minimum measurements. This information is summarized in Table 12.

Table 12. Ranges in three measurement data.

Character	Cycle I	Cycle II	Cycle III	Cycle IV
Ear height, cms.	47	42	18	11
Days to half-silk	16	4	4	3
Growing-degree days	297	103	51	51

Yield was not included in these ranges, because of widely differing yields in the various seasons and cycles. It will be noted in Table 12 that the ranges decline in magnitude as the cycles advance. This is considered another indication that the population is approaching genetic equilibrium.

Sorghum Breeding, Samaru (Full Season)

D. A. Andrews

Variety trials

Tests on local sorghums selections were conducted at three sites in the Southern Guinea zone. Breeding work continued at Samaru to produce dwarf, adapted lines both for use as varieties and parents for experimental hybrids. For the third year, yield tests were carried out in the Sub-Sudan and Northern Guinea Savannas on lines and a hybrid from Samaru. The response of dwarf sorghum to population increase, date of planting and to some inter-planting practices was investigated.

Local cultivars

Trials containing selections from the Mokwa program were continued at three sites Kaiama, Ganye and Lowlands where conclusive evidence had not been obtained from previous trials. Results up to 1969 from Kaiama and Lowlands are shown in Table 13.

Current recommendations are summarized in Table 14 and show that selections produced from tall local cultivars in the main Savanna zones in northern Nigeria have recorded yield increases of up to 26%.

It is now recommended that cultivar C 7-4-2 should be recommended at Kaiama and, depending on the preference between C 7-4-2 (which is white seeded) and FD 1 (yellow seeded), both should be recommended at Lowlands.

Table 13. Sorghum variety trials - Kaiama and Lowlands

Selection	Kaiama						Lowlands					
	1967 kg ha	1968 kg ha	1969 kg ha	Mean kg ha	Mean lb/ac	% Gain of Selection	1966 kg ha	1968 kg ha	1969 kg ha	Mean kg ha	Mean lb/ac	% gain of Selection
Site local	1446	927	489	954	851	--	908	723	1182	937	836	--
C7-4-2	2008	1176	834	1340	1195	40.4	1308	1097	1377	1261	1125	34.6
FD1	2005	1165	1442	1537	1371	61.1	1175	890	1620	1229	1096	31.1
B17-8-2	1731	1082	743	1185	1057	24.2	1280	893	1249	1141	1018	21.8
ML 4	1527	1157	743	1142	1019	19.7	1111	828	1194	1045	932	11.5
Mokwa local	1711	1176	781	1223	1091	28.2	1132	912	1267	1104	985	17.8
SE	$\pm$ 106	$\pm$ 53	$\pm$ 222	--	--	--	$\pm$ 53	$\pm$ 49	$\pm$ 152	--	--	--
LSD 5%	316	156	301	--	--	--	155	145	206	--	--	--

Table 14. Summary of yield gains of selections from local sorghum cultivars in the Savanna zones of Nigeria.

Zone	Selection	Number of trials	Yield of local Kg/ha	Gain of selection		
				%	Kg/ha	lb/ac
Sudan Savanna	YG5760-3-10	36	1438	18	281	251
Eastern Sudan Savanna	G 59	5	860	111	954	851
	G26-3-1	5	1270	26	331	295
Guinea/Sub.Sudan Savanna	SFF60	13	1226	6	74	66
	FFBL3-1-6	18	1362	20	272	243
Southern Guinea Savanna	C7-4-2	19	1150	25	288	257

Dwarf sorghums

Breeding was contained at Samaru on the production of dwarf varieties, and dwarf hybrid parents suitable for use in the Sub-Sudan and Northern Guines Savanna zones in northern Nigeria.

A replicated variety trial containing 15 dwarf lines and one hybrid was planted at 10 locations from Zuru to Mubi. Accompanying this trial were larger observation plots of four selected dwarf varieties. The overall results from these trials are not yet available so the preceeding 1968 trials are reported in Table 15. Yield totals of three of the 1969 trials are shown in Table 16.

Dwarf varieties and hybrids permit the use of higher rates of fertilizer (42 lb P_2O_5; 63 lb N per acre) in trials as against 21 lb/acre each of P_2O_5 and N which is used in trials on the tall cultivars.

The 1968 trials showed Short Kaura, Line SK 5912 as the best yielder at an average of 2,160 lb/acre. This being a Kaura type is yellow seeded. Amongst the white or pearly seeded lines 2084, 2403, 2141 and 2123, though lower yielding, are of interest because of their preferred seed quality. In these trials, lines were not separated according to their height and it was suspected that the shorter (3-dwarf) lines were not expressing their proper yield potential because of competition with the lines of medium height (2-dwarf). In the 1969 trials the 2- and 3- dwarf lines were kept in separate blocks and it is evident that the 3-dwarf lines on an average have given yields comparable to the 2-dwarf group.

Replicated trials were carried out on reselections made within the lines 2403, 2123, 2141 and 2347 and significant yield differences were found among the selections within the 2403 and 2123 lines.

Observation plots, of about 1/20 ha each, similar to those planted at outstations, were planted at Samaru using two hybrids and seven varieties. The best yield was recorded in spite of bird damage by a 2 x 3-dwarf hybrid, SH 2 which gave 3,049 lb/acre. Short Kaura 5912 gave 2,855 lb/acre and line 2123 gave 2,202 lb/acre.

The fourth cycle of recombination was made in the male sterile breeding bulk which is maintained by 10 percent mass selection amongst male sterile plants. A general decrease in seed size has been noticed in this bulk, but desirable segregates are appearing which are taken out for pedigree selection. Specific crosses were made to introduce large grain size, resistance to grain weathering and tan plant colour, together with good head exsertion to create sub-populations which will be integrated after some screening.

Table 15. 1968 Sorghum dwarf lines trials. Grain yields of 32 entries at 6 locations in the Guinea and Sub-Sudan Savanna zones of Nigeria, Samaru, N.T.C., Shika, Bauchi, Zuru and Hong.

Line Type1/	Mean yield Kg ha	Mean yield lb/ac	Agronomic data - Samaru Height	Agronomic data - Samaru Heads per plant	Agronomic data - Samaru Time of heading3/	Maigana Striga rating4/
5912 SK2/	2421	2160	2.27	1.03	0	xxx
2736 (CK-SK)SK	2370	2114	2.57	1.26	- 1	xx
93 x 5764 Hybrid SH1	2250	2007	1.50	1.10	- 6	xx
2710(CK-SK)SK	2192	1955	2.35	1.21	- 5	xx
2643 (CK-SK)SK	2103	1876	2.20	1.26	- 4	xx
2659 "	2085	1860	1.47	1.07	- 4	x
2082 CKB-SKMDW	2007	1790	2.02	1.04	- 5	x
2608 (CK-SK)SK	1917	1710	2.25	1.22	- 4	x
2084 CKB-SKMDW	1912	1706	1.90	1.04	- 6	x
2347 SKMDW	1907	1701	1.37	1.00	+ 1	xx
2721 (CK-SK)SK	1803	1608	1.37	1.00	- 1	0
2077 CKB-SKMDW	1766	1575	2.05	1.02	- 2	x
2355 SKMDW	1743	1555	1.32	1.00	0	0
2770 (CK-SK)SK	1722	1536	1.40	1.13	- 5	xx
4424 (CK-SK)SK	1704	1520	1.47	1.00	- 4	xx
2743 "	1695	1512	1.40	1.19	- 7	xx
2403 CK-RC	1668	1488	1.17	1.00	-10	0
5764(CK-SK)SK	1637	1460	1.35	1.13	- 2	xx
2141gSK-Wx	1614	1440	1.95	1.47	+ 1	xx
2624(CK-SK)SK	1532	1367	2.25	1.12	0	xxx
- WX2/	1512	1349	1.65	1.43	-12	xx
2123 CK-FF	1499	1337	1.32	1.49	- 6	xxx
2510(CK-FF)FF	1407	1255	1.32	1.09	- 4	xx
2504 "	1392	1242	1.37	1.00	- 6	xx
2471 "	1303	1162	1.40	1.27	- 4	x
2125 CK-FF	1273	1136	1.25	1.00	- 7	xx
2405 CK-RC	1208	1078	1.32	1.11	- 4	0
2367 Heg-FF	1195	1066	2.30	1.14	- 1	xxx
2493(CK-FF)FF	1174	1047	1.65	1.10	-11	x
2127 CK-FF	1054	940	1.20	1.38	- 7	xx
2384 Heg-SK	784	699	1.07	1.06	-11	0
2922gSK-DDS	1420	1267	1.00	1.20	-13	x
Exp. mean	1659	1480	--	--	--	--

1/ SK - Short Kaura; gSK - irradiated Short Kaura; WX - Hegari x Farafara Sel. CK - Combine Kafir 60; MDW - Makaho da Wayo; FF - Farafara; Heg - Hegari; DDS - double dwarf Shallu; RC - CK x Galb-el-Jackus

2/ SK and WX are regarded as control varieties in the 2 & 3-dwarf ranges.

3/ Days before (-) or after (+) the date of heading for Short Kaura(1.10.68)

4/ Tolerance to Striga: 0; none, x poor, xx moderate, xxx good.

Table 16. 1969 Dwarf lines trials, Zaria area. Grain yields in Kg ha. (not analysed)

Line	Site: Samaru V3	Site: Samaru S8	Site: Shika	Average: Kg ha[1/]	Average: lb/ac	Height m.
3 dw. Lines						
1879 CK-RC	1823	2774	2582	2393	2135	1.31
SH1 Hybrid	2366	2548	2231	2382	2125	1.32
2659 (CK-SK)SK	2264	2049	2389	2234	1993	1.22
2743 "	2016	2174	2129	2106	1879	1.17
2123 CK-FF	2242	1755	2253	2084	1859	1.15
2347 SKMDW	1494	2095	1710	1767	1576	1.15
2493(CK-FF)FF	1336	1619	1472	1475	1316	1.27
2772(CK-SK)SK	1143	1438	1110	1231	1098	1.00
Mean	1871	2095	2021	1995	1780	--
2dw. Lines						
5912 SK	3601	1676	3996	3091	2757	2.02
2710(CK-SK)SK	2627	1381	2570	2193	1956	1.79
2227 WX-SK	2559	1370	2513	2148	1916	1.54
2141 gSK-WX	1880	1347	2921	2049	1828	1.72
1228 "	1970	1290	2468	1909	1703	1.69
60 WX	1642	985	1325	1317	1175	1.50
2084 CKBSKMDW	1472	906	1540	1306	1165	1.62
2079 S/KB(CK-Kur)	1121	340	1416	958	855	1.40
Mean	2018	1179	2388	1862	1661	--
Overall Mean	1945	1660	2205	1929	1721	--

Three experimental hybrids trials were conducted containing 8, 13 and 9 entries which gave mean yields of 2,267 lb/acre; 2,555 lb/ac. and 2,027 lb/acre, respectively. The hybrids, which are made by crossing selected lines out of a common female line tend to flower earlier than their parents and this year suffered bird damage because of this earliness. The best yields in the three trials were given by the hybrid with line 1905 CK-SK (Combine Kafir x Short Kaura selection) at 2506 lb/acre line 1794 (CK-SK) SK at 2,876 lb/acre and in the third trial variety Short Kaura itself at 2,732 lb/acre as it did not sustain any bird damage.

A number of potential female lines have been made from various origins, and experimental hybrid seed has been produced on the A lines which will be entered into yield tests planted next May.

Short Kaura Line 5912 is now recommended for the Zaria and Zonkwa areas.

Line 2123 is recommended in the Zaria area (from Samaru results) where a short-stemmed white seeded variety is preferred to Short Kaura. Line 2123 is recommended in addition to, and not in replacement of FFBL-3-1-6, which has the highest quality white seed. Under conditions of moderate to good fertility at populations of 20,000 to 30,000 plants per acre line 2123 may be expected to yield between 2,000 lb/ac and 2,500 lb/ac, occasionally higher. This is between 30 and 40 percent more grain than that expected of improved Farafara. The grain quality is not as high as Farafara but the flour is acceptable. The protein content is the same or slightly higher. Being between 1.2 and 1.5 m tall, line 2123 can be mechanically harvested. While only one year's results are available it is probably that line 2123 is also suitable for intercropping, particularly with millet which is commonly grown with sorghum.

Line 2123 is also recommended for cultivation at Daudawa. Previous observations, 1958-1960 showed that Daudawa Farafara was equivalent to Samaru Farafara, and indicated a yield level of 1,550 lb/acre for the local Farafara. The variety trial at Daudawa failed in 1968. In the 1967 trial the progenitor of 2123 gave 2,700 lb/acre and in the 1969 observation plots recorded 2,042 lb/ac.

Proposals for new recommendations of dwarf sorghums in other areas depend on favorable 1969 results.

At each location where recommendations are made, foundation seed will be supplied to the Ministry of Natural Resources for multiplication and distribution.

Agronomic Investigations - Crops

Investigations were conducted on a number of factors influencing the yield of the new dwarf sorghums as typified by line 2123. A trial was carried out on plant population and on date of planting.

Plant population:

An increase in yield of 36 percent was recorded in 1968 when the population of line 2123 was increased from 14,500 ppa to 29,000 ppa keeping the rectangularity the same. This however has practical difficulties for row crops and therefore in 1969 the effect of four different population densities were measured keeping the distance between rows at 24 inches which permits cultivation during crop growth (Table 17). The plant populations used were from 10,890 to 76,230 plants per acre. The best yield 2125 lb/ac, though not high, was given by the treatment with 54,450 ppa. An increase in population from this to 76,230 ppa resulted in a significant drop in yield of 19 percent. Work on plant population should becontinued investigating both density increases and effects of changing rectangularity within densities.

Date of Planting

This experiment was designed to measure the effect of date of planting on grain yield and other characters, comparing a dwarf sorghum, line 2123 with FF BL 3-1-6, an improved Farafara typical of the tall Nigerian cultivars. Eight dates of planting at weekly intervals were used, planting commencing as early as possible which was on 17th May. This was after a total of 4 inches of rain had fallen in the previous few days but a dry period of 30 days followed in which only 2.2 inches of rain were recorded. The two varieties were planted at their optimum plant densities, 14,500 plants per acre for the large FF BL 3-1-6 plants and 29,000 for the dwarf 2123, and the same rates of fertilizer 49 kg per ha - P_2O_5 and 90 kg per ha N were applied to both.

The results, Table 18, showed a significant effect of date planting on the yield of grain and total dry matter produced and also a large difference in grain yield between the varieties; 2123 gave an average of 71% more grain than FF BL 3-1-6 and with minor differences both varieties reacted the same way to date of planting.

The first date of planting did not give the highest grain yield and the best yields were obtained from the second to the sixth planting, 24 May to 21st June.

Table 17. Dwarf sorghum line 2123, Plant population trial.

Plant Population per acre	Distance between plants in row (inches)	Grain yield kg/ha	Grain yield lb/ac
10,890	24	2142	1911
32,670	8	2278	2032
54,450	48	2382	2125
76,230	34	1919	1712
	SE.	± 122	± 109
	LSD.5%	261	233

Table 18. Sorghum date of planting experiment. Grain and total dry matter yields in Kg/ha

Variety	17/5	24/5	31/5	7/6	14/6	21/6	28/6	5/7	Mean
2123 Grain	2055	2889	2801	2984	2598	2672	2123	1187	2414
T.D.M.	14459	14568	12425	12845	11312	10105	7847	5134	11087
FFBL3-1-6 Grain	1268	1485	1797	1478	1024	1824	1261	1139	1410
T.D.M.	19227	19736	19613	16507	16222	15632	11170	9074	15898

SE (Grain) ± 68

This is contrary to the expected pattern of the highest yields being given by the first two or three plantings followed by a decline which is later accentuated by pests and diseases. On examining the total dry matter production it can be seen this conforms more closely to the expected. Shoot fly counts showed no attack on the initial planting, building up slowly at first, until the latest planting on 5th July were 40 percent of the stands of FF BL 3-1-6 had at least one dead-heart and 60 percent on 2123.

Though the effect of date of planting on the grain yield of the two varieties was similar it is noted that during the optimum period 24/5 to 21/6 the yield level remained more consistent with Line 2123 than with FF BL 3-1-6.

Sorghum Improvement at Kano
A. O. Abifarin

The sorghum program at Kano is directed towards the breeding of genotypes that are adapted to the Sudan Savanna Zone. The primary objectives are to breed improved varieties and hybrids with better nutritional qualities, to study and devise means for the control of long smut (Tolyposporium ehrenbergii), to conduct agronomic studies on the effect of plant populations, date of planting, and fertilizers. The results of a part of the 1969 work are reported.

Rainfall was adequate throughout the growing season. The crop was free of insect pests with the exception of some midge on plots adjacent to early materials.

Variety trials

The West African Sudan Savanna Yield trial was grown at Kano (Table 19). The highest yield of 3005 lbs per acre was made by NK-300 on nearly four times the local check variety. Other varieties were superior to the check variety in yield. The variation in yield between the entries is reflected in the variation in threshing percentage. Greater attention must be given to learning why the low threshing percentage of sorghums growing under this environment.

The same group of early hybrids reported from Samaru was also included in a trial at Kano (Table 20). Of the 18 in the test, 8 gave yields equal to or better than the check hybrid, NK-300. Although these hybrids give relatively high yields they are about 40 days earlier than the local varieties. Varieties of this maturity are better adapted at Daura, 90 miles north of Kano. Farmers have asked for seed of NK-300 for horse feed and as an

Table 19. Grain yield and other agronomic data from the Sudan Savanna Regional Yield trial, Kano 1969.

Entry	Days to bloom	Height cm	Threshing %	Yield kg/ha	Yield lbs/ac
SH 11	82	410	21	730	654
CSH 1	58	155	65	2951	2634
1371-62	75	200	73	2604	2325
NK-300	69	185	63	3366	3005
Serena	79	190	44	947	845
Dobbs	89	180	30	712	637
3 D x 57/1E	78	175	57	1801	1609
H x 60/7/2A	91	180	13	1897	1693
5 D x 160/4/1	92	190	11	143	128
5 D x 36/1/2	89	200	27	296	265
IS 9290	79	140	59	1546	1381
C 9357	78	165	53	1310	1171
C 9358	76	140	54	2024	1808
7199	59	140	56	2400	2144
C 10461	76	155	59	2361	2109
C 9411	69	140	41	2076	1854
S 29	91	400	39	998	891
Hegari	61	157	75	1332	1190
Kano Local	106	270	51	895	799
YG 5760-3-10					
CE 90	67	180	70	2106	1880

Table 20. Yield and other agronomic data from early sorghum hybrids at Kano, 1969.

Entry	Days to bloom	Height cm	Threshing %	Yield kg/ha	Yield lbs/ac
CK-60 x SA7706-1-2	62	210	58	3846	3434
CK-60 x SA7706-5-1	69	210	47	2566	2291
CK-60 x IS 84-1	61	160	65	3587	3202
CK-60 x IS 84-2	55	165	66	4456	3979
CK-60 x IS 3691	69	160	57	3455	3085
A 172 x 82-1	67	155	56	1996	1746
A 172 x 84-2	61	206	62	2334	2084
A 172 x 3691	67	195	46	1694	1513
A 3675 x 84-1	69	160	47	1113	994
A 3675 x 3691	79	180	32	1040	929
A 2219 x 84-1	57	145	64	2976	2657
A 2219 x 84-2	63	145	58	1711	1528
A 2219 x 3691	72	155	43	1174	1049
A Martin x 84-1	58	140	69	1533	1369
A Martin x 84-2	69	180	53	2046	1827
A Martin x 3691	67	180	50	1428	1275
NK-300	74	240	46	2335	2084
4-dw Kafir 7706-1-1	63	165	51	2380	2125

insurance crop for their own food if their local varieties fail. Food has been prepared by women in Kano from brown seeded sorghums and although the color is darker than they normally would accept they would eat it if there was a supply and if it were less expensive than the local types. There is much breeding work to be done in order to get the combinations of high yield, grain quality, proper maturity, disease resistance, etc into a single variety.

The other nursery material included: the West African Sudan Observation nursery, 65 hybrids from DeKalb and 8 from the Pacific Oil Seeds Company in the U.S.A., 94 early F_4 lines, 204 late F_4 lines, and 129 inbreds and segregating lines from the sorghum breeding project in Lafayette, Indiana. Most of the latter were known to be high in protein and lysine and some with high yield potential. Intercrosses were made between these lines and local varieties.

A collection of 54 local varieties were included in an evaluation trial in 3-row plots. Samples of grain from these will be evaluated for protein content.

Date of planting

NK-300, our best U.S.A. hybrid, and Zauna Inuwa our best local variety plus two other locals were included in this experiment. The object was to investigate the effects of planting dates on yield and the possible interaction of varieties x dates of planting (Table 21). The results show a progressive decrease in grain yield as planting is delayed, which supports the recommendation of planting as soon as possible after the first planting rain. Each week delay gave a loss of 395 to 469 lbs per acre.

Table 21. Yield, threshing percent, days to 50 percent bloom. Height of four varieties planted on four dates.

	NK 300				Zauna Inuwa			
	June		July		June		July	
	18	25	2	9	18	25	2	9
Grain yield kg/ha	1360	870	520	380	1540	1020	690	180
lbs/ac	1210	775	465	340	1380	910	615	159
Threshing Percentage (%)	36	55	35	44	39	34	28	50
Days to 50% bloom	87	82	81	74	115	109	103	97
Height cm	155	140	140	150	205	180	210	165

	YG 5670-3-10				JANJARE			
	June		July		June		July	
	18	25	2	9	18	25	2	9
Frain Yield kg/ha	1545	1110	946	361	2070	980	790	200
lbs/ac	1380	990	845	320	1845	880	715	175
Threshing Percentage (%)	48	50	30	59	56	56	56	40
Days to 50% bloom	108	103	98	95	90	93	90	90
Height cm	365	340	350	270	260	220	200	185

Early Sorghum Varieties and Hybrids
Sweet Stalked Sorghums, Samaru
O. J. Webster

The sorghum varieties which were included in the Regional west African Sudan Savanna trial were grown at Samaru together with several other early maturing hybrids. Although the material is out of its environment at Samaru it does give an opportunity to evaluate their potential.

Seed of a few sweet stalked sorgos was obtained from the experiment station at Maradi, Niger in 1966 and have been included in yield trials at Samaru.

Yield trials

The two grain sorghum yield trials were planted in plots, 2 rows wide spaced at 2 feet x 20 feet in length. The varieties and hybrids which were included in the Regional trial were planted at a rate of 45,000 per acre, Table 22. Yields ranged from 925 lbs. per acre for NB 6250 to 4842 lbs. per acre for NK-300. Four other hybrids similar to NK-300 gave yields of over 4000 lbs. per acre. Serena was best of the varieties from Uganda. All varieties from Uganda have brown seed except 5 D x 36/1/2 which has white seed and a tan stalk. CE 90 from Senegal also has white seed and a tan stalk. The yield of CE 90 was reduced due to poor stand. Sorgho 29 from Upper Volta is a tall, early maturing variety all of the grain was eaten by birds prior to harvest.

Five cytoplasmic male-sterile A lines were pollinated with three fertile R lines to produce seed of 15 hybrids. These hybrids were tested with four others produced by crossing Combine kafir-60 A and 4-dwarf Combine kafir-60 A with white hegari strains (Table 23). This trial was planted at a rate of 89,000 per acre. The yield level was not increased by doubling the population as exemplified by the yield of 4842 lbs. per acre for NK-300 at the lower rate and 4434 lbs. per acre from the higher rate. The yields of the hybrids with the white seeded hegari lines as a pollinator ranged from 4298 lbs. per acre to 5114 lbs. per acre for 4-dwarf CK-60 x S.A. 7706-1-1. This high yielding hybrid should do very well in the Sudan Savanna zone but seed production would be a problem in this area.

The mean yields of the 5 hybrids with a common pollen parent were (lbs per acre):

IS 84-1	IS 84-2	3691
2807	3161	3819

The mean yields of the 3 hybrids with a common seed parent were (lbs. per acre):

Combine kafir-60	A 172	A3675	A2219	A Martin
3092	3590	2357	3536	3735

Table 22. Yields and other agronomic data from sorghum varieties grown in the Regional West African Trial plus others of local interest, Samaru 1969. Date planted June 11. Plot size, 2 rows spaced 2 feet apart x 20 feet long.

Entry	Source	Days to bloom	Plant ht. cm	Yield lb/ac	Yield kg/ha
NK 300	USA	66	210	4842	5423
C-9357	USA	64	185	4787	5361
NK 10453	USA	65	155	4406	4935
C-9411	USA	65	145	4162	4661
C-10461	USA	65	145	4080	4570
Serena	Uganda	79	230	3101	3473
137-62	Niger	70	215	4026	4509
IS 9290	Nigeria	74	150	3840	4301
CSH-1	India	62	155	3019	3381
C-9358	USA	66	150	2910	3259
3D x 57/1/E	Uganda	78	220	2802	3138
C 7199	USA	59	135	2693	3016
RS 703	USA	56	125	2230	2498
CE 90	Senegal	67	170	2094	2345
RS 690	USA	52	115	1986	2224
H x 60/7/2A	Uganda	88	200	1877	2102
Redlan x YE 8189	USA	56	135	1795	2010
Dobbs	Uganda	89	250	1496	1676
5D x 36/1/2	Uganda	87	250	1523	1706
SH-11	Mali	74	330	1414	1584
5D x 160/4-1	Uganda	88	250	1142	1279
NB 6250	USA	54	95	925	1036
Sorgho 29	Upper Volta	79	350	taken by birds	

Table 23. Yields and other data from early maturing sorghum hybrids grown at Samaru, 1969. Date planted June 11, Plot size 2 rows spaced at 2 feet x 20 feet long.

Entry	Days to bloom	Plant wt. cm	Stover grain ratio	Lodging %	Yield lbs/ac	Yield kg/ac
Ck-60 x SA 7706-1-2	70	210	2.2	5	4597	5149
Ck-60 x SA 7706-5-2	68	220	2.1	10	4787	5361
CK-60 x SA 6645-1-4-2	60	205	1.8	20	4298	4814
4 dw Ck-60 x SA7706-1-1	65	165	1.6	0	5114	5728
Ck-60 x IS 84-1	63	160	2.4	0	3019	3381
Ck-60 x IS 84-2	61	180	2.7	15	2557	2864
Ck-60 x IS 3691	72	200	2.9	0	3700	4144
A 172 x IS 84-1	63	190	1.3	25	3155	3534
A 172 x IS 84-2	62	190	1.8	15	3509	3930
A 172 x IS 3691	77	260	3.0	10	4107	4600
A 3675 x IS 84-1	62	150	2.2	20	1795	2010
A 3675 x IS 84-2	62	170	2.1	0	2421	2712
A 3675 x IS 3691	78	195	2.9	0	2856	3199
A 2219 x IS 84-1	63	140	2.0	0	2720	3046
A 2219 x IS 84-2	61	165	1.3	5	4270	4782
A 2219 x IS 3691	70	170	2.6	0	3618	4052
Martin x IS 84-1	59	155	1.6	0	3346	3748
Martin x IS 84-2	59	180	1.8	0	3046	3412
Martin x IS 3691	70	180	1.8	15	4814	5392
NK-300	66	190	1.7	30	4434	4966

The two hybrids which looked the best in the field were 4-dw Combine kafir-60 x SA 7706-1-1 and A 2219 x IS 3691.

The productivity of early maturing varieties at Samaru is demonstrated each year. The reason for not recommending such varieties is because of the poor grain quality resulting from the crop maturing during the rains. The threshing percentage of this type of material is lower than expected. This may be due to stem borers which reduce translocation into the seed. With insect control, good soil fertility and high plant population some of these hybrids should give yields of at least 8000 lbs. per acre.

The center portion of the stalks of most west African sorghum varieties are dry and pithy. Few have sweet juicy stalks. This is probably due to the greater damage to the sweet stalks resulting from the fungi which enter the stalks through holes left by stem borers. In the case of normal stalks, borer damage is usually confined to the area inhabited by the borer. On the other hand, rotting may occur in a few internodes above or below the hole left by the borer in a sweet juicy stalk.

A few sweet stalked varieties from Niger have been included in trials (Table 24). These are full season types and give a high yield in the absence of borers. This year on a green weight basis they gave yields of 60,000 lbs. per acre.

Breeding

In addition to the three yield trials, the Regional West African Observation nursery was grown at Samaru.

Breeding for early maturing types at Samaru has largely been phased out and is being transferred to Kano.

Dr. Doggett from Serere, Uganda provided seed of his sorghum composites developed by using a genetic male-sterile. This material does not hold much promise here. A composite using male-sterile-3 is being formulated using as parent stock the varieties in the Sudan Savanna regional trials as well as the earliest maturing local varieties.

Table 24. Yield of three sweet stalked sorghum varieties, Samaru 1969. Origin, Niger. Planted June 11, harvested October 10.

Entry	Yield lbs. per acre green wt.	Yield lbs. per acre dry wt.	Yield kg per ha green wt.	Yield kg per ha dry wt.
62-16	67592	18249	75703	20439
62-19	59024	14756	66017	16527
62-24	54264	14651	60775	16509

Pearl Millet, Samaru 1968
O. J. Webster

The millet improvement program in Nigeria is directed by Dr. B. D. Bhardwaj, Institute for Agricultural Research, Kano. Dave Andrews and I cooperate with him by conducting a limited program at Samaru. Stanley King, cereal pathologist, works closely with us by taking notes on downy mildew and smut.

The objectives of the program are to develop shorter stalked varieties less subject to lodging, profuse tilling, and resistance to downy mildew and smut. Eventually the lines being developed will be used as parents for hybrids.

Yield test

In 1967, 129 S_1 lines from Ex Bornu were top crossed to a population of Ex Bornu improved by 2 cycles of mass selection. The lines were grown in alternate rows with Ex Bornu with plants speced 2 feet apart to avoid sibbing between plants within a line as much as possible. Tillers were removed from the plants in each line and spikes were harvested which bloomed at the same time as the male parent. Seed of 35 of the topcrosses with Ex Bornu as a check was planted in a 6x6 lattice (Table 25). The results are most gratifying since it was not known how successful this method of topcrossing would be. The stands in the trial were nearly perfect. There were no significant difference between the mean yields of the replications and no adjustment of plot yields was required. The yields of the test were very good for this crop. Remnant seed of the 10 top S_1

Table 25. Top cross trial of lines from Ex Bornu crossed by reselected Ex Bornu, Samaru, Nigeria, 1968. Date planted May 17, plot size--single rows spaced 3 feet x 20 feet.

Entry Line No.	No. of plants: Total	No. of plants: Downy Mildew	Yield per plot (gms): 1	Yield per plot (gms): 2	Yield per plot (gms): 3	Yield per plot (gms): 4	Yield: lbs/ac	Yield: kg/ha
51	81	3	2141	2208	2569	2088	3602	4037
59	84	8	2597	2045	2225	2130	3599	4034
88	82	7	1939	2540	2243	2094	3526	3952
48	81	4	2366	2031	2361	1949	3483	3904
64	83	7	1964	2362	2139	2236	3480	3901
117	84	1	1762	2655	2212	1915	3418	3831
89	84	2	2368	2311	1666	2139	3394	3804
50	84	3	1753	1989	2141	2468	3340	3744
39	84	1	1974	2181	2109	2078	3337	3740
40	84	5	2248	1969	1896	2037	3260	3654
55	82	13	1867	1746	2096	1941	3060	3430
35	84	12	2002	1948	1802	1891	3057	3426
60	81	7	1272	2237	2071	2003	3033	3400
48	84	1	1982	1890	1727	1982	3032	3398
118	84	10	1701	1784	1965	2032	2993	3355
87	84	9	1621	1824	2047	1894	2954	3311
61	84	11	2019	1700	1858	1791	2947	3303
82	84	3	1670	1979	1839	1830	2927	3281
98	84	7	1856	1902	2023	1481	2905	3256
60	84	14	1734	1627	1912	1896	2868	3215
45	84	5	2331	1285	1810	1721	2859	3205
91	84	9	1792	1618	1923	1789	2849	3193
106	84	6	1968	1761	1663	1675	2827	3169
116	84	2	1848	1652	1537	1918	2782	3118
94	84	8	1963	1833	1834	1209	2736	3067
74	83	12	1644	1867	1485	1839	2734	3064
88	84	8	1216	2246	1339	1994	2718	3046
46	84	8	1487	1864	1528	1821	2680	3004
Ex Bornu	84	7	1681	1648	1515	1723	2627	2944
94	84	5	1252	1763	1708	1678	2560	2869
43	83	9	1734	1450	1734	1466	2554	2863
53	83	14	1620	1449	1438	1795	2521	2826
70	84	9	1623	1678	1351	1470	2449	2745
41	82	8	1485	1254	1346	1874	2384	2672
118	84	6	1446	1143	1658	1344	2236	2506
87	83	4	993	1440	1522	1575	2212	2479

LSD - 543 lbs/acre, 609 kg/ha
CV = 6.5%

lines was planted in soil blocks and transplanted in a polycross type of nursery in the 1968/69 irrigated nursery. The first planting was chewed off by some insect so a second planting was made but seed will not mature in time for yield testing in 1969. This trial demonstrated that this method of breeding can be used to improve the crop. An improved Ex Bornu will be of value as a population to draw on in the breeding program but not as a variety to release since the objectives listed above do not call for an improved Ex Bornu but an entirely new model.

Breeding

Dr. G. Burton, Tifton, Georgia provided seed of 241 F_1 hybrids produced by crossing lines derived mostly from west African material onto male-sterile 23 A. Most rows had 10 to 15 plants. All plants in 118 F_1 rows and 87 male rows were infected with downy mildew. Selfed seed was harvested from 45 of the F_1s and 20 of the male lines. The seed from the F_1 plants will be grown and short segregates selected.

Over 400 selfed lines from Ex Bornu were grown in order to screen them for resistance to downy mildew and smut. Selfed seed from several lines with no plants showing symptoms of downy mildew was harvested. We hope to be able to find resistance in the local material. The number of smutted selfed heads was much less than in 1967. This could be due to a seasonal effect but we hope it may reflect selection for resistance. If we can get resistance to both diseases then we'll have very valuable breeding material.

Seed of a few maiwa (photoperiod sensitive) lines supposedly resistant to downy mildew was introduced from Upper Volta in 1965. Crosses were made with Ex Bornu lines and F_2 population grown this season. Early maturing segregates were selected and will be progeny tested in 1969. No mildew has been noted in those maiwa lines at Samaru. There seems to be more resistance in this same type millet being grown in Nigeria. The lines from Pankshin with yellow endosperm are maiwa. These have been crossed to male-sterile 23 A and 230 A. The F_1s were fertile and we hope to be able to select early, short statured lines with yellow endosperm.

Several selfed lines from Ex Bornu have been crossed to 23 A. About 20 B lines have been identified and A lines are being developed by backcrossing. These lines may not be of any value in a hybrid program since we require "dwarf" lines.

The seed from the fertile F_1 hybrids from Ex Bornu lines x 23 A has been grown in order to select short plants which may be of value as R lines in hybrids or possible release as varieties. Breeding work is in progress to develop short statured A and B lines from local strains.

Millet Improvement - Kano, Nigeria

Bhup D. Bhardwaj

The major objectives of pearl millet improvement in Nigeria are to develop lines and hybrids productive of grain with resistance to lodging, downy mildew, and smut, for cultivation in the Sudan Savanna zone. Most of the programme is carried out at Kano in cooperation with the personnel of the OAU--STRC Joint Project 26. A small project is carried out by Dr. Webster at Samaru.

Among thecultivated pearl millets in Nigeria only two types GERO (*Pennisetum typhoides* Stapf. and Hubb.) and MAIWA (*P. Maiwa* Stapf and Hubb.), are extensively grown. The third type, DAURO, considered to be a specialized type of MAIWA, is grown as a transplant crop in very restricted areas. DAURO, being of lesser importance, has not yet been taken up for further improvement. The purpose of this report is to give information on the progress made so far in pearl millet improvement in Nigeria.

Yield testing

Yield trials with GERO populations collected within Nigeria were discontinued, as some populations have been identified to be promising for future use in a breeding programme. One such population is 'Ex Bornu' from Bornu Province in North Eastern State of Nigeria.

Yield testing of MAIWA populations was continued at five locations in the northern states. Being a late season crop, the results are still awaited.

A number of strains received from Uganda, Niger Republic, and Mali were grown in observation plots at Kano and Samaru to evaluate them for use as straight introductions or for use in the breeding programme. Results for the strains, which had reached maturity at the time of writing this report, are given in Table 26.

Table 26. Grain yields and other agronomic data from recent pearl millet introductions in Nigeria.

Pedigree	Origin	Plant height in cm		Days to bloom		Yield per acre in lbs	
		Kano	Samaru	Kano	Samaru	Kano	Samaru
Ex Bornu	Samaru	237	260	47	50	1098	3960
6A	Uganda	207	210	44	40	1083	2810
M-2	Ghana	200	190	42	38	1065	2073
17	Uganda	207	190	43	40	1044	2569
10LB	"	209	200	46	41	974	3495
3A	"	239	210	45	40	859	3183
P-3 (Kolo)	Niger	210	320	55	53	817	2259
26/9	Uganda	202	220	46	44	750	3287
26/19	"	198	200	44	41	643	1671
ZONGO	Niger	220	330	49	52	590	3261
LOCAL	Kano	229	-	49	--	497	--

Breeding projects

1) Isolation of inbred lines - Inbreeding in collections of both GERO and MAIWA was continued. Total number of inbreds now available at the station are:

Crop	Number of inbreds	Stage of inbreeding
GERO	1505	S_3
MAIWA	211	S_2

It is proposed to carry forward these inbreds for 2-3 cycles of inbreeding and eventually use them in a hybrid program.

Inbreeding was also continued to isolate inbreds with special characters. The number of lines available now are as under:

Crop	Character	No. of inbreds	Stage of inbreeding	Remarks
GERO	Bristled	35	S_2	Possible use as bird resistance
GERO	Venetian color(Red)	6	S_2	Genetic marker
GERO	White seed	16	S_2	-
MAIWA	Dwarf	62	S_2	-

The heights of the dwarf lines range from 85 to 125 cm, whereas the average height of a normal MAIWA crop is 245 cm.

2) Production of cytoplasmic male-sterile lines resistant to downy mildew - Tift 23A and other introduced cytoplasmic male-sterile lines were found to be highly susceptible to downy mildew in Nigeria. The attack of downy mildew is so heavy that all plants die at seedling stage. It appears that the millet breeders in Senegal, Niger Republic and Cameroun also are faced with the same problem. For this reason it is considered necessary to develop cytoplasmic male-sterile lines and maintainers with more tolerant Nigerian varieties. Some crosses were made by Dr. Burton, in Tifton, Georgia, with the Nigerian material supplied by my predecessor, Mr. Gymer; but when the progenies were grown in Nigeria they met the same fate as the male-sterile lines. Since Tift 23 has been grown successfully in India, in spite of the fact that the downy mildew is present in that country, it appears that different biotypes of _S. graminicola_ may be involved in causing this disease in Nigeria. As such, all selection for resistance to this disease will have to be done under local conditions.

Crosses between Tift 23A x Ex Bornu population were made in nursery during 1967 dry season. The F_1's were found to be all fertile, indicating the absence of sterility genes in this population of GERO millet. As such, it was not possible to develop even tall cytoplasmic male-sterile lines by simple backcrossing. The method now being used is outlined below:

1967 dry season -	Tift 23A x Ex Bornu	
1967 wet season -	F_1	All plants fertile. Selected plants selfed.
1967-68 dry season -	F_2	Progenies grown in nursery and selected plants crossed onto Tift 23B.
1968 wet season -	Tift 23B x F_2	Progenies grown in field. Plants showing tolerance/resistance to downy mildew selfed.
1968-69 dry season -	(Tift 23B x F_2) selfed	Progenies grown in nursery and each selected plant was selfed and crossed onto Tift 23A. In all, 224 test crosses were made.

1969 wet season -

i) Early in the season the test crosses with Tift 23A were sown in field and checked for sterility. Fifteen (15) crosses were found to be completely sterile.

ii) Late in the season the remnant seeds of the 15 crosses which were found to be completely sterile were planted. At the same time, selfed seeds of the male parent of these 15 crosses were also planted. Selected plants from the test crosses will form base material for isolating A lines and those from selfed progenies for B lines. By crossing and selecting for another 2-3 generations it should be possible to isolate downy mildew resistant lines with other desirable characters from Tift 23, by the end of 1970. These lines will then be used in testing with inbred lines for producing F_1 hybrids.

Crosses were made during 1967-68 dry season between Tift 23A and five populations of MAIWA, collected from MAIWA growing areas in Nigeria. Of the 237 F_1 progenies scored during the 1968 wet season, 6 were completely sterile, 121 completely fertile, and 110 segregated for sterility. This indicates that the sterility genes are present in MAIWA populations. Efforts are now being made to isolate A and B lines. Since Tift 23A is day neutral and MAIWA daylength sensitive, it will be possible to isolate A and B lines of both photosensitivity types.

3) Production of improved strains of GERO and MAIWA for immediate use - Tift 23A x Ex Bornu, GERO millet crosses made in the 1967 dry season, have been carried through F_5 generation in progeny rows. Selection has been made for downy mildew and smut resistance/tolerance, lodging resistance, higher tiller numbers, height and other agronomic characters. Bulks (prefix KG) of the F_5 progenies were put into yield test together with 4 other entries. These yield tests were conducted in1969, at Kano, Maradi in Niger Republic, and Bambey in Senegal. Available results are presented in Table 27. The performance of a number of the new strains compares favorably with the average grain yield of 538 lb/ac of millet in Nigeria. Some of these strains also compare favorably with the existing improved populations of GERO in cultivation in Nigeria. For comparison the yields of these improved populations, recorded in yield trials up to 1967, are shown in Table 28. The seed of these new strains is now being multiplied and it is proposed to yield test it extensively.

Table 27. Grain yield and other agronomic data from new strains of GERO millet in 1969 trials. Plot size - three ridges 30 ft. spaced 2 ft. apart at Samaru and 2½ ft. at Kano.

Pedigree	Plant height in cm			Days to bloom			Yield per acre in lb			Stand at harvest per plot	
	Kano	Samaru	Av.	Kano	Samaru	Av.	Kano	Samaru	Av.	Kano	Samaru
Samaru 68/local	212	242	226	49	50	50	823	3323	2116	35	57
Syn-1	209	202	206	49	47	48	2010	2456	2233	26	54
Ex Bornu	210	238	224	52	53	53	1367	2368	1868	24	47
Samaru 67	199	234	217	53	53	53	1026	2109	1567	46	44
KG 40	161	147	154	46	50	48	1888	1839	1864	58	55
KG 58	174	176	175	53	51	52	1671	1779	1725	51	53
KG 52	167	168	168	50	53	52	2226	1561	1894	44	54
KG 62	158	198	178	54	55	55	--	1537	(1537)	--	54
KG 69	159	154	157	49	47	48	1065	1375	1220	40	55
KG 6	159	156	158	52	50	51	1791	1271	1531	51	54
KG 12	162	154	158	46	50	48	1270	1162	1216	45	54
KG 34	157	184	171	55	43	49	823	1093	958	42	54
KG 71	173	166	170	50	57	54	496	1000	748	47	55
KG 70	153	154	154	49	47	48	2130	948	1539	63	56
KG 67	152	152	152	53	48	51	1235	908	1072	43	52
KG 22	140	129	135	45	51	48	1307	799	1053	53	54
KG 10	141	130	136	43	42	43	1125	645	885	52	56
KG 9	148	129	136	44	40	42	774	508	641	43	55
KG 21	124	114	119	45	41	43	--	383	(383)	--	54

Table 28. Grain yield in lb per acre of existing strains of GERO millet.

Variety	1967 Kano	1967 Av. over 10 locations	Average over 5 years Kano	Average over 5 years Av. over 10 locations
Ex Bornu	625	940	1025	945
Ex Bauchi	726	905	1091	935
Ex Benue	787	933	972	952
N6	492	860	1033	952
B5	747	904	948	944
Local	620	888	874	892

A similar programme for isolation of new strains of MAIWA and GERO from Tift 23B x MAIWA populations is now in F_2 stage. From the segregating generations it should be possible to isolate both GERO and MAIWA type strains resistant to downy mildew and possessing desirable characters of both Tift 23B and MAIWA populations.

4) Other breeding projects

i) Evaluation of modified mass selection. Third cycle of selection has been completed in Ex Bornu population of GERO millet. To estimate the advance made per cycle, the resulting material will be yield tested next year.

ii) Study of inbreeding depression in MAIWA. One more cycle of inbreeding will be completed this year in five populations of MAIWA. This will bring the total to four inbreeding cycles. It is proposed to estimate the inbreeding depression in these five populations next year.

Miscellaneous

i) Different populations of GERO and MAIWA millets and the new strains of GERO were multiplied in isolation for future use.

ii) Seed of Tift 23A and Tift 23B was multiplied during the dry season.

Entomology

G. T. York

Work was continued along lines mentioned in previous reports and dealt mainly with shoot flies, stem borers and the sorghum midge.

The stem borer population was so low on experimental plantings that only cursory tests were made.

Shoot flies

The work on shoot flies is a joint undertaking between Mr. J. C. Deeming, Curator of the Insect Collection of the Institute for Agricultural Research and myself. Mr. Deeming handles all of the taxonomic work while I do the field studies.

Our original concept of the shoot fly problem, judging from the literature, was that only one species of shoot fly was important. Early work indicated several species were present and important on the cereals in the Samaru area. In 1968 (Fifth Annual Report) 30 species had been recorded, but not all of these were pests of cereals. The species were listed in the Report, with pertinent data on each species.

The work this year, together with identifications coming in from previous collections, has increased the number of species of shoot flies to 79. However only 25 of these have been reared from cereals. The others were from grasses and miscellaneous collections.

In the genus Atherigona, in which *Atherigona varia soccata* Rond is undoubtedly the most important species on a worldwide basis, we now have 53 species. Of these only 18 have been described. Mr. Deeming is busy on the taxonomic characters for describing the new species.

Additional work on the seasonal abundance of shoot flies was carried on in 1969. For the major work only sorghum was used. This consisted of two rows of NK-300 and 2 rows of IS 3592, each 40 yards long. The seeding rate was in the neighborhood of 6 to 10 seeds per linear foot of row. The first planting was made on June 12 and continued at approximately two week intervals until September 25.

The two varieties NK-300 and IS 3592 had been selected for this work as it was hoped that these plants could also be used at the end of the season for determining the resistance of IS 3592 to the sorghum midge. NK-300 is quite susceptible to the midge and should serve as a reservoir for a high population of the midge. Unfortunately the shoot fly population was so destructive from the fourth planting on that none of the plants reached the flowering stage.

In spite of fairly uniform rates of planting, the resulting germination and growth was a bit erratic. The planting of July 24 was in quite wet soil and was followed by heavy rains. Although the emergence of NK-300 was moderately good that for IS 3592 was extremely poor. In other plantings considerable bird damage was encountered when bush fowl dug up seeds and early germinated plants. Although a "bird boy" was employed for early morning and late afternoon, it was found that mid-day damage was occurring. With two boys and dawn to dusk surveillance bird damage was eliminated.

The total number of plants infested with shoot flies or different planting dates is shown by the following figures:

Planting date	Plants infested	
	NK-300	IS 3592
June 12	29	9
June 27	715	215
July 11	1031	478
July 24	601	---
August 9	798	347
August 23	862	292
Sept. 6	874	522
Sept. 25	572	---

It may be noted that only the June 12 planting had a light infestation of shoot flies. All others were heavily infested. On the basis of normal planting rates this would be virtually 100 percent infestation.

The results this year were somewhat different from last year in that the population remained high through September. Last year the maximum population was in mid-August and dropped off quite sharply in September.

The highest incidence of attack was from the second to fourth week after planting. This is in accordance with general observation of other workers. However infestations continued through the eight and ninth week when plants were nearing the "boot" stage. This late infestation has been mentioned in previous reports. Only by actual dissection of plants can one be sure if the infestation is shoot fly or stem borer.

The two systemic insecticides were finally obtained and tested for shoot fly control under local conditions. These were phorate (Thimet) and disulfoton (Solvirex). Both were granular formulations. Both had been tested before in other countries and were known to be effective. These tests were to determine efficiency and dosage rates under Nigerian conditions.

Two tests were made. In both the insecticides were applied in a continuous band ina shallow trench two inches deep then covered. Planting was done the same day with a small hand planter.

In the first experiment the rate of application was five pounds per acre. Solvirex was in both 5 and 10 percent formulation and Thimet at 10 percent. Results after five samplings showed the following control: Solvirex 5% - 17, Solvirex 10% - 38 and Thimet 10% - 87. This showed quite clearly that the application rate for Solvirex was not sufficient for control. Most of the infestation in the Thimet treatment was in the first replicate, indicating a light application in this particular replicate.

In the second test the application rates of Solvirex were increased to 10 and 20 pounds per acre. Also to determine if there might be a deleterious effect from a higher rate of Thimet, this was used at 5 and 10 pounds per acre. Results of this test, following three sampling periods, are as follows:

Treatments	Rate per ac.- lbs.	No. infested plants	Percent control
Solvirex 5%	10	166	73
" 5%	20	47	92
" 10%	10	87	86
" 10%	20	17	97
Thimet 10%	5	30	95
" 10%	10	14	98
Check -	--	621	--

The percentage figures might be somewhat misleading. The planting rate in this test was higher than for normal field planting. Thus in the case of Solvirex 5% at 10 lbs. per acre with 166 infested plants the percentage figure might, under normal planting rate, be only 40 or 50 percent control.

The difference between Solvirex 5% at 20 lbs. per acre and Solvirex 10% at 10 lbs. per acre could be due to experimental error or possibly better distribution of the 20 lb. rate making it more available to the plants.

Solvirex 10% at 20 lbs. per acre and Thimet 10% at 5 and 10 lbs. per acre gave very satisfactory control. Thimet appeared to have a stimulating effect on early plant growth. No adverse condition could be detected from the higher rate of Thimet.

Additional work is planned with these insecticides, particularly in relation to machine applications at planting time. Also another promising insecticide, carbofuran (Furadan) has been air shipped and hopefully will arrive in time for testing next season, both as a seed dressing and soil treatment.

Stem borers

The work on stem borers was seriously reduced this year due to a low borer population. The experimental planting of June 3, specifically for borer control work, had virtually no borers and it was felt that the application of insecticides would be a waste of time.

A moderate infestation was noted later on in a planting made for student observations. This was a rather small field and only two replicates were possible. A hand operated, positive feed, granular applicator had been constructed by the Agricultural Engineering Section of Institute for Agricultural Research. This was used for applying the granular insecticide. Unfortunately it had not been properly calibrated for the different granules and quite varying amounts, all on the low side, were applied. Nevertheless the results, serving only as an indication of possibilities, are given:

Material	lbs per acre	Borers after treatment
Gardona 10%	6.0	3
Solvirex 5%	2.2	17
" 10%	2.8	18
Solvigan 10%	5.8	4
Ekatox 5%	2.2	5
Thiodan 5%	9.8	1
PP-511 5%	3.4	5
Check -	-	18

Even at the very low dosages some of the materials looked quite promising. Thiodan, which proved so successful last year, had the best kill but also had the highest application rate. Additional tests are planned for next season.

The granular applicator should prove quite useful in future small-scale testing. The positive flow action resulting from the rotation of a small wheel eliminates the possibility of clogging which was so common with the straight gravity flow action. It might also be adapted for small acreage work if conditions warrant.

Sorghum midge

The sorghum variety IS 3592, which was noticed by Dr. Webster in 1966 as appearing to have marked resistance to the sorghum midge has been grown each year since then. Although it has appeared to maintain this resistance the midge population was not carefully checked so there has been a question as to whether it was actually resistant or whether it flowered and developed when the midge population was low.

This season sequential plantings were made at approximately two week intervals with two varieties NK-300 and IS 3592. The NK-300 was to build up and maintain a high midge population sothat regardless of flowering time of the IS 3592 it would be subjected to a high midge population. As mentioned under shoot flies, these plantings were to combine both shoot flies and midge studies. Unfortunately after the third planting the shoot fly damage was so severe that no flowering of either variety took place, hence the status of IS 3592 remains unchanged. Future plans are to treat with systemic chemicals to control shoot flies and thus assure proper development of both varieties.

Insects attacking sorghum heads

Damage to developing sorghum seeds by the true bugs or plant bugs (Hemiptera) has been suspected for some time. Injury is caused by these insects piercing the seed and sucking out part of the contents. This results in shrivelled and often non-viable seed. Damage appears to be mostly on improved varieties and hybrids, rather than local varieties.

In experimental plants of NK-300 this year at least four species of plant bugs were present. Populations were as high as 40 and 50 insects per sorghum head. Both adults and nymphs were present indicating that reproduction was occurring on the sorghum plant. Actual damage could not be determined as there were no insect-free heads,

but it was assumed to be in the neighborhood of 50 percent. Also at the Nigerian Tobacco Company's experimental farm near Samaru severe damage to a variety developed by the Institute for Agricultural Research was noted. This was not observed during the growing season but was brought to my attention at harvest time when heads had failed to develop properly. This damage was undoubtedly due to earlier feeding by plant bugs.

Additional work needs to be done to determine the total number of species involved, the extent of damage under different population levels, varietal differences and methods of control.

Maize insects

Maize in the Samaru area has been relatively free of insect injury. Although shoot flies have been reared from young seedlings the degree of infestation has been very light even on mid-season plantings when the shoot fly populations were at their highest. During the rainy season stem borers have been noted but not in damaging numbers. On irrigated maize the stem borers, Sesania spp. have caused the loss of some plants. This season the false codling moth Cyptophlebia leucotreta was found to be quite abundant, feeding mostly on the silks, but with an occasional kernel being consumed. In all cases observed pollen germination had occurred before thesilks were destroyed so there was no crop reduction.

If maize production increases in the sorghum growing areas, as it might well do judging from experimental results, the pest complex needs to be carefully followed to note any changes that might lead to injurious populations.

Trip to Ghana

In September I visited the Experiment Stations at Kumasi and Tamale. At Kumasi, Dr. S. Endrody Younga has worked for some time on maize pests, particularly the stem borer Sesamie botanephaga. The life history and ecology have been given in a recent publication, "The stem borer Sesamia botanephyaga Tams and Bowden (Lep. Noctuidae) and the maize crop in central Ashanti, Ghana, published in Ghana Jour. Agric. Sci. 1, 103-131(1968). Of special interest to me were his results with insecticides which werenot given in the publication. Of some 50 insecticides tested at high dosage levels, none gave sufficient control to warrant additional testing.

At Tamale in the northern part of the country, sorghum and millet are the main crops. No entomologist is stationed there. The plant breeder, Mr. H. Mercer-Quarshie stated that shoot flies and stem borers were not a serious problem. A mid-July planting of NK-300, which would be seriously attack by shoot flies in the Samaru area, was in excellent condition and served as a verification of his statement. The sorghum midge was considered the most important pest of the area. Although some work had been done on breeding for resistance to the midge, Mr. Mercer-Quarshie did not feel that the varieties he had to work with had sufficient resistance to warrant additional work.

Sorghum and Millet Pathology
S. B. King

Cereals pathology at the Institute for Agricultural Research, Zaria, is directed almost entirely toward the two crops, sorghum and pearl millet (Pennisetum typhoides). Diseases are presently not serious on maize grown in the northern parts of Nigeria, and thus the maize pathology aspect of this project has been handled almost entirely by Dr. Craig at Ibadan.

The primary objectives of the sorghum and pearl millet pathology program are to identify the major diseases of these crops in west Africa and to develop methods for control. The most practical control method for most diseases on these crops is the use of resistant varieties. Hence, considerable effort goes into the identification of resistant materials and the development of artificial inoculation techniques for those diseases in which natural epiphytotics are not sufficiently reliable for screening purposes.

Sorghum

Leaf diseases

Most of the leaf diseases reported for sorghum can be found in west Africa, but presently they do not constitute an economically important problem. The local varieties which have probably been grown by farmers in this area for centuries are quite tolerant to most leaf diseases. Low fertility, low plant populations, and intercropping, which presently characterize most sorghum production in west Africa, are additional deterrents to the development of epiphytotics of these diseases in farmers fields.

However, with the introduction of new, higher yielding varieties and a more intensified type of crop production, several leaf diseases are likely to become serious problems.

During the years 1965 through 1968 data were obtained on the reaction of the world sorghum collection to natural epiphytotics of several leaf diseases including anthracnose (Colletotrichum graminicola), sooty stripe (Ramulispora sorghi), oval leaf spot (R. sorghicola), zonate leaf spot (Gloeocercospora sorghi), and downy mildew (Sclerospora sorghi). Screening the collection for resistance to leaf diseases was not continued during 1969 because seed of a new collection from India did not arrive in time for planting. Seed of resistant lines will be increased and made available to sorghum breeders.

Smuts

All four of the smuts reported on sorghum occur in Nigeria and are probably present throughout the sorghum growing areas of west Africa. Yield losses due to these diseases are estimated at 8 to 10 percent, annually. Most of this loss could be avoided if farmers treated seed with an inexpensive fungicide prior to planting. The very limited use of fungicidal seed treatment can be attributed to inadequate knowledge by farmers and poor distribution of fungicide.

Observations during 1967 and 1968 indicated that a great amount of variability exists in the soral characteristics of covered smut (Sphacelotheca sorghi) in Nigeria. It was suspected that these differences might represent different physiologic races of S. sorghi. Hence, a study was initiated to determine the amount of physiologic variability which occurs. Twenty-five isolates of S. sorghi were tested against six differential host varieties, Dwarf Yellow Milo, Pierce Kaferita, White Yolo, Hegari, Combine Kafir-60 and Short Kaura. Isolates had been collected from both Caudatum and Guineense types, and represented a wide range of soral characteristics and geographical locations throughout northern Nigeria. Eight isolates gave a clear reaction for physiologic race 4 and one for race 2. Most of the remaining isolates resembled race 4, but their identity was not clear. Including other varieties among the host differentials might indicate a greater amount of variability than was shown by this investigations.

Other host response studies with several isolates of covered smut generally showed that: (1) kafirs, hegaris, shallus, and darsos are highly susceptible, (2) milos, kaoliangs, sudangrasses, and sorgos range from highly resistant to susceptible, and (3) feteritas are either immune or highly resistant. Evidence was also obtained for increased virulence within isolates successfully passed through resistant hosts.

The physiologic race situation for loose smut (*S. cruenta*) was also investigated. Six isolates of the fungus collected from different locations within Nigeria were tested against a set of five differential host varieties including Reed Kafir, Pierce Feterita, White Yolo, Kafir x Feterita, and Red Amber x Feterita. Three isolates clearly reacted as physiologic race 2, two others resembled race 2, and one isolate did not resemble any of the three known races of loose smut.

Loose smut infection is generally thought to be caused by seed-borne spores which infect the plant only at the time of seed germination. Some observations recently made in Nigeria seem to indicate that a systemic infection which is not controlled by a seed dressing can be caused by soil-borne spores at a later stage in plant development. This matter is being further investigated.

Attempts to infect sorghum with head smut (*S. reiliana*) and long smut (*Tolyposporium ehrenbergii*) by artificial inoculation were not successful. The inoculation technique used for head smut involved hypodermic injection of *S. reiliana* sporidia into the growing points of 5 to 6-week old plants. Failure to obtain infection was likely due either to avirulent inoculum or inoculation of plants at too late a stage of maturity. Artificial inoculation of long smut involved atomizing sporidia of *T. ehrenbergii* onto sorghum flowers at various stages of floral development. Lack of success in producing infection was thought to be due to either avirulent inoculum or adverse microenvironmental conditions for infection of the sorghum head at, or immediately following, the application of inoculum. Investigations on artificial inoculation of both diseases are being continued. A one-half acre head smut nursery with a heavy infestation of soil-borne teleospores is being established for screening varieties for resistance to *S. reiliana*.

Ergot

Only traces of the honey dew phase of ergot (*Sphacelia sorghi*) are observed in farmers' fields in Nigeria. However, male sterile sorghum lines become heavily infected when grown at Samaru. Because of the high susceptibility of male sterile lines, ergot could become a major problem for hybrid seed production. Avenues of research on this disease are directed toward (1) determination of the time of year when natural infection occurs, and (2) testing the effectiveness of fungicides for control of the disease.

Observations on natural infection made at Samaru during the the past three years indicate that (1) natural infection does not occur prior to the second week of September, (2) natural infection does not occur in plots which initiate flowering after the first week in November and which are located at a distance from infected plots, and (3) new infections continue to occur naturally at least until February on tillers of plants located in plots initially infected in September. These observations suggest that hybrid seed of long season sorghums could be produced in the Samaru area free of ergot if planting were delayed such that flowering occurred 5 to 7 weeks later than normal.

Six fungicides were tested for control of ergot on a male sterile line. Sprays were applied to heads at 0.15 and 0.30 percent concentrations and at 3 and 5 day intervals for a two week period starting from the time heads emerged from the boot. Benlate, Thiabendazole, and Captan significantly reduced infection at both concentrations when applied at 3 day intervals. Plantvax, Vitavax, and Ziram did not reduce infection to a level significantly below that of control heads sprayed with water.

Witchweed

Witchweed (*Striga hermonthica*) is an important parasitic weed on sorghum throughout much of Africa. An effort is being made to locate resistance to this weed by growing the world sorghum collection on *Striga* infested soil. Since the world collection was not available during 1969, 40 sorghum varieties representing a wide range of grain sorghumtypes were tested for their reaction to this parasite. *Striga* reaction was scored on the basis of the amount of chlorosis and necrosis which developed in sorghum leaves as a result of infection. The resistance of hegaris, sorgos, kaoliangs, and kafirs was moderate to very low, whereas that of feteritas and milos was high. Spur Feterita, Feterita Wad Hussein, Finney Milo, Dwarf Shallu, F.C. 6606 Darso, and Dobbs showed no apparent *Striga* damage. Combine Kafir-60 is an extremely susceptible host and serves as an excellent indicator for the presence of viable *Striga* seed in a field several weeks in advance of the actual emergence of *Striga* plants above the soil level.

Millet

Downy mildew

Downy mildew or green ear (Sclerospora graminicola) is the most serious disease of pearl millet in west Africa. Losses due to this disease in Nigeria are estimated to approach 8 to 10 percent, annually. Much of the downy mildew program is conducted in collaboration with the millet breeder at Kano.

Identification of resistant material is the primary objective of the downy mildew program. During the past three years data have been collected on the reaction of a world millet collection to downy mildew. Over 1800 lines have been scored on two occasions for reaction to downy mildew, and an additional 700 lines have been scored once. A total of 85 lines showed a two-year infection score of 5 percent or less. Entries originating in Nigeria or Niger showed the highest type of resistance to natural infection. Some fifth generation dwarf bulks from crosses between the extremely susceptible variety, Tift 23, and selections of a relatively tolerant Ex-Bornu population showed fairly good resistance to downy mildew both at Kano and Samaru.

Natural epiphytotics of downy mildew apparently occur annually in northern Nigeria, and they are generally adequate for screening materials for resistance. However, some data obtained during the past three years indicate that susceptible lines do occasionally escape infection and respond as resistant lines. An artificial inoculation technique developed in India in which germinating seeds are exposed to infection by asexual spores of S. graminicola is being investigated as a possible method for distinguishing between resistant materials and mere escapes.

Smut and ergot

Smut (Tolyposporium penicillariae) and ergot (Claviceps microcephala) are commonly found in Nigeria, but they are presently not of any great economic importance. However, foreign materials, which are introduced into the breeding program because of desirable agronomic characters, are generally very susceptible to both of these diseases. Efforts are underway to locate sources of resistance. Heads bagged for breeding purposes usually become heavily infected with smut. Hence, several fungicides were tested to locate one which could be used by breeders to reduce the incidence of smut on bagged heads.

Since bagging heads apparently produces an ideal environment for infection by T. penicillariae, it was used to facilitate obtaining information on the reaction to smut infection. Several heads of each of 48 millet selections were bagged and scored for their reaction to

smut. Thirteen selections showed a level of resistance equal to, or better than, that found in Ex-Bornu which showed a 6 percent level of infection.

Difficulty was encountered in scoring for reaction to ergot because of the apparent daily variation in natural infection caused by weather conditions. Artificially inoculating open flowers by spraying them with conidia from the honey dew phase increased the intensity of infection, but time did not permit the use of this technique for screening for ergot resistance during the past year.

Fungicides were found to reduce the incidence of smut when sprayed with a hand atomizer onto heads immediately before bagging at the time the first flowers began to open. One application of a 0.225 percent concentration of Plantvax, Benlate, Vitavax, Ziram, Captan, and Thiabendazole reduced average infection to 0.6, 2.8, 4.6, 5.9, 18.2, and 30.2 percent infection levels, respectively, as compared with the 40.8 percent average infection recorded on unsprayed checks.

Observations on the incidence of ergot and smut were made on susceptible materials planted in three different rainfall areas: 1) Samaru (high), Kano (medium), and Tarna (Maradi), Niger (low). Smut infection was high at all three locations, but ergot, which was high at Samaru and Kano, was absent at Tarna. This suggests that ergot might not be a potential threat to millet in areas of low rainfall, whereas heavy smut infection does occur at both low and high rainfall areas.

Soil Management

The Effect of Plant Population and Nitrogen on Sorghum Varieties

K. R. Stockinger and Ango Abdullahi

In 1968 Mr. Andrews of the Botany Section carried out a plant population and nitrogen study with five varieties. The responses and yield levels were disappointing but it was felt that the early end of the rains had reduced yields, especially at high plant populations. Because of this the experiment was rather inconclusive and further work was needed.

To study this further, three of the most promising varieties were used in a trial to determine the response surface of population and nitrogen for each variety. Using a composite design for the experiment, plant population was varied from 14,000 to 58,000 and nitrogen from 0 to 200 pounds of N. The plants were spaced at equal intervals in a grid pattern so that each plant was equidistant from other plants in all directions for each population.

The yield levels of the trial were quite disappointing and were 1430, 1560, and 1780 pounds per acre as the maximum for each of the three varieties. The low yield was from the double dwarf variety, which was more severely attacked by stem borers. The highest yield was from the triple dwarf variety and the mid-yield from the triple dwarf hybrid. All plots had good stands and grew vigorously throughout the season. Only one variety, the hybrid, gave a significant response to nitrogen and population. The response surface is dome-shaped with the maximum at 100 pounds per acre of nitrogen and 37,000 plants per acre. However, the magnitude of the response is so small (240 pounds per acre) that it is uneconomic under the best of conditions.

The yields of these varieties were disappointing in other trials this year. Last year lack of moisture at the end of the season appeared to limit yield, but this year the rains continued until the end of October and moisture was not limiting. No further studies with plant population and nitrogen on sorghum varieties are planned for the next year.

Date of Planting

K. R. Stockinger

The importance of planting maize as early as possible after the rains start has long been recognized in tropical Africa. In East Africa date of planting affects yield more than variety or fertilizers. Why this is so has not been satisfactorily answered. To see if the effect was due to the rains moistening the soil and keeping it moist or to less favorable climatic conditions, a trial was started this year using some old abandoned drainage lysimeters. Half of the lysimeters were covered with plastic sheets to prevent the soil from being moistened by the rain. The other half were allowed to receive the rain as it fell. Half of each of these sets of plots were planted on May 16 and the remainder on June 23.

The table below shows the marked effect on the June 23 planting of a soil which had not received any moisture prior to planting compared to a soil which received rainfall normally.

Date of planting	Covered	Uncovered
May 16	3500	4300
June 23	5700	2200

At the early planting date the covered plot had difficulty in establishing a stand because of lack of moisture storage in the profile and consequently this treatment was off to a slower start.

Since sunshine, air temperature, and humidity were the same on both sets of plots on the late planting, the effect must be due to some depressing effect caused by the rains prior to planting. This may be due to the leaching of available nutrients by the early rains, poor aeration, or reduction in soil temperature by the cooling effect of the evaporation of water from the soil surface. Since nitrogen and phosphorus were supplied at high rates at the time of planting, it is doubtful if leaching could be a large factor. The amount of rain which had fallen by June 23 was not great enough to have raised the water table and inhibited aeration. No measurements of soil temperature were made on the soil at the late planting date because the crop was inadvertently planted on June 23 instead of July 15 as originally planned. I was on leave at this time and was surprised to find the crop planted when I returned on the 7th of July.

In the light of the large effect due to planting date and soil moisture, additional experiments are planned for the coming year to discover the mechanism involved. An experiment similar to the one described above will be carried on the same site with an additional treatment. Two-thirds of the lysimeters will be covered and at each planting date one set of the covered lysimeters will be supplied with the amount of water which has fallen since the start of the rains less the evaporation losses. These plots should be similar to the uncovered plots except in the effect of time of wetting on the soil. Soil temperatures will be monitored in all plots after planting until differences cease to be measurable between treatments. An irrigation experiment is also planned for the spring before the start of the rains to determine the effect of light, frequent waterings compared to heavy, infrequent waterings on the growth of maize. One set of plots will be kept wet for amonth prior to planting to simulate moisture conditions at a late planting. Since temperatures are highest during this period, soil temperature effects should be less important but they will be monitored. A third experiment with four dates of planting at four fertility levels will be carried out during the normal growing season. Dry matter production samples will be taken at periodic intervals throughout the growing season. This will enable us to determine when the date of planting effect occurs and what stage of growth it affects. These experiments should answer some questions as to the factor or factors involved in date of planting. The above experiments will be carried out in cooperation with Dr. Kowal and Dr. Jones of the Soil Science Section of the Institute for Agricultural Research at Samaru.

Soil Fertility Field Trials

K. R. Stockinger and R. G. Heathcote

In 1968 trials were carried out at the Institute for Agricultural Research field stations at Samaru, Kano, and Mokwa to test the needs for nitrogen, potassium lime, and trace elements using sorghum and maize as the test crops. They showed a general response to nitrogen, a response to potassium at Kano and Mokwa, and a response to trace elements at Samaru. Trace elements also enhanced the response of potassium at Mokwa. Lime did not give a response at any of these sites.

In 1969 the trials at Samaru, Kano and Mokwa were continued and additional trails were started at seven other sites scattered throughout northern Nigeria. The new trials are not functioning properly as yet and will have to be changed to get meaningful results. The trace element treatment was not applied because the fertilizer containing trace elements was lost on the docks at Lagos. Several sites were located on areas with extreme soil variation, resulting in poor experiments. At other sites errors in applying the treatment are evident and the results are questionable. It was necessary to use crops other than sorghum or maize at the sites for rotation or lack of adaptation of the crop. Cotton, groundnuts, and millet were used at some sites.

In general there was a large response to nitrogen at all sites which have reported, showing that nitrogen is generally limiting. Kano and Mokwa show responses to potassium and Samaru and Kano a response to trace elements. At Kano there is also a positive interaction of nitrogen and potassium, each giving a greater response in the presence of the other element. At none of the other locations was there a response to treatments other than nitrogen.

Chemical analysis of these soils shows that Kano and Mokwa are very low in exchangeable potassium and Kano is also low in exchangeable magnesium. It is proposed that magnesium be added to the trace element plots at Kano to see if there is any response.

Several long term trials at Samaru, Mokwa, and Kano are planned to study the effect of sources of nitrogen on yield and soil properties. These will be carried out in cooperation with the Agronomy Section. The principal aim of these studies is to see if the various sources are equally efficient and also to see the effects they have on the soil chemistry.

Another study is also planned to study the effects of heavy application of nitrogen, phosphorus, and potassium fertilizers on the long term yields and soil chemistry. This will be carried out in cooperation with Dr. Jones of the Soil Science Section at Samaru only.

Long Term Effects of Continuous Cultivation on Nutrient Balance of Tropical Savanna Soils

K. R. Stockinger

Most of the soils of the tropical savannahs of west Africa are low in clay content and organic matter. Also, the clays which do occur in these soils are primarily kaolinite, resulting in soils with a very low base exchange capacity. This results in a poorly buffered soil which will be affected by any addition of cations. To see how large this may be and what the effect of continuous applications of fertilizer is, the long term DNPK experiments from Samaru and Kano were examined. Because of the availability of the Atomic Absorption Spectrophotometer purchased by the project this year, we were able to examine exchangeable calcium, magnesium, and potassium in detail on soil samples from all plots. Also the potassium chloride exchangeable acidity was determined as well as pH and organic matter.

The responses of the various factors to the treatments are shown in the following table.

Factor	Samaru Mean Value m.e./100g	Treatments D	N	P	K
Base exchange capacity	1.52	+	-	+	NS
Exchangeable calcium	.91	+	-	+	NS
Exchangeable magnesium	.25	+	-	NS	NS
Exchangeable potassium	.16	+	-	NS	+
Exchangeable acidity	.20	-	+	-	NS
Organic carbon per cent	.25	+	NS	+	NS
pH(in 1/100 M $CaCl_2$)	4.6	+	-	+	NS

Kano

Factor	Mean Value m.e./100g	D	N	P	K
		Treatments			
Base exchange capacity	1.13	+	-	NS	NS
Exchangeable calcium	.76	+	-	+	-
Exchangeable magnesium	.20	+	-	-	-
Exchangeable potassium	.10	+	-	-	+
Exchangeable acidity	.08	-	+	NS	NS
Organic carbon percent	5.4	+	NS	NS	NS
pH (in 1/100 M $CaCl_2$)	.08	+	-	NS	NS

The fertility treatments were 0, 1, and 2 tons dung per acre; 0, 56, and 112 pounds of ammonium sulfate per acre; 0, 56, and 112 pounds of single superphosphate per acre; and 0, 25, and 50 pounds of potassium chloride per acre applied for seventeen years to a sorghum, groundnuts, cotton rotation. All plot residues were removed. The analyses were done on samples from the surface six inches.

The addition of dung had a favorable effect on all factors studied and ammonium sulfate fertilizer had the opposite effect on everything except organic carbon, which was not changed. Adding single superphosphate also adds calcium to the soil, which increased the calcium content of both soils but decreased the magnesium and potassium at Kano. At Samaru the increased growth of the crops due to phosphorus left a large residue of roots in these soils and increased the organic carbon content of the soils and the base exchange capacity. Potassium fertilizers increased the exchangeable potassium at both locations but decreased the exchangeable calcium and magnesium at Kano. This shows that the addition of small amounts of a cation can displace other cations and cause their removal from the upper layers of soil. If higher rates of fertilizers are used the effect on exchangeable magnesium may be quite serious, resulting in a severe reduction in this element. At Kano the magnesium levels have been reduced to .12 m.e. per 100 gms on some sets of plots and may be limiting yield. Exchangeable potassium shows similar effects at both locations and heavy applications of other cations in nitrogen and phosphate fertilizers could also result in reductions in exchangeable potassium and potassium deficiency in many of these soils.

The soils of the two areas differ in the fact that Kano's is coarser textured but has a higher organic carbon content. Also the effect of ammonium sulfate on soil acidity is much less at Kano than at Samaru. The plots which received 112 pounds per acre of ammonium sulfate per year had 0.22 m.e./100g of exchangeable acidity at Kano compared to 0.67 m.e./100g on similar plots at Samaru. Deeper samples need to be investigated at bothlocatations to see how deep these effects have penetrated. Treatments which affect the organic carbon level and the pH of the soil also affect the base exchange capacity of the soil.

The better balance of the cations in the dung plots as well as the higher pH and exchange capacity may partially explain their continued productivity compared to plots which receive only commercial fertilizers. Continued removal of all crop residues aggravates the problem by reduction in organic matter levels in the soil as well as accelerating the removal of nutrients not supplied by fertilizers. If crop residues cannot be returned to the soils, at least the ash from the burned crop residues should be returned to reduce the losses of calcium, magnesium, and potassium.

Training

K. R. Stockinger

I will be serving as the advisor for two graduate students in the coming year, Mr. Roy E. Pfaltzgraff, Jr., an American missionary born in Nigeria who wishes to get a master's degree in soils, and Mr. Ango Abdullahi, a member of the Agronomy Section who plans to go to North Carolina for course work and return to Ahmadu Bello University for his thesis work and Ph.D. degree. I have also trained a technician in the operation of the Atomic Absorption Spectrophotometer.

EAST AFRICA

The PASA research operations in East Africa involve maize breeding at Kitale, Kenya; finger and pearl millet breeding, entomology investigations and soil-plant-water-fertility studies at Serere, Uganda and Cereal processing and nutrition studies at Nairobi, Kenya. As in West Africa our operations are cooperative with local research personnel. This cooperation is indicated by the authorship of the following sections.

Regional Activities
East African Cereal Research Conference

The Third Eastern African Cereals Research Conference was held in Zambia and Malawi on March 10-15, 1969. The conference was attended by 43 scientists from ten countries. Tours were arranged of Mount Makulu and Chitedze, the main research stations of the host countries. Conference sessions were held on methods of breeding, agronomic research, grain legumes, extension methods and regional cooperation. The importance of the conference and of regional cooperation was stressed in addresses by the Honorable R. C. Kamanga, Minister of Rural Development, Zambia and the Honorable G. C. Chakwamba, Minister of Agriculture, Malawi. Tentative plans were developed for the next conference to be held in Ethiopia in October 1970.

The 1967-68 Eastern African Maize Variety Trial
L. H. Penny

A regional maize variety trial was initiated for growing in the 1966-67 season to identify some of the best maize varieties available for particular environments in Eastern Africa and to study their range of adaptation. Those trials were grown in Ethiopia, Kenya and Uganda. The data from those trials tended to confirm previous observations that altitude and length of rainfall period are the major factors affecting the adaptation of maize varieties in this part of Africa. The Kenya hybrid H632 and the Zambian hybrid SR 52 were clearly superior at the medium altitudes (4,000 to 5,000 feet). Those two hybrids were superior to local farmers' varieties also at higher altitudes, but Kenya hybrid H 613B gave higher yields above 6,000 feet. The extreme height and long period to reach flowering of the two Kenya hybrids were objectionable under some conditions. SR52 was both shorter in height and somewhat earlier flowering. The Kenya hybrid H511 was still earlier flowering and would be preferable under a rainfall period too short for H 613B, H632 or SR52 to reach full development before being damaged by a lack of moisture. None of the locations of the 1966-67 trial had a sufficiently short rainfall period to require the short season Katumani maize.

A second Eastern African Maize Variety Trial was prepared for growing in 1967-68. The following entries were included:-

	Variety	Source
1.	H632	Kenya
2.	H613B	Kenya
3.	H511	Kenya
4.	Katumani V x Katumani VI	Kenya
5.	(Northern Hemisphere) Jimma (Jimma)	Ethiopia
5.	(Southern Hemisphere) L.H. 11	Malawi
6.	SR 52	Zambia
7.	Askari Comp.	Malawi
8.	Zambia Local Comp.	Zambia
9.	White Star	Uganda
10.	Ilonga Comp.	Tanzania
11.	Embu Comp. I.	Kenya
12.	Embu Comp II.	Kenya
13.	Ukiriguru Comp. A	Tanzania
14.	Kitale Comp. E	Kenya
15.	(Northern Hemisphere) Jimma (Alemaya)	Ethiopia
15.	(Southern Hemisphere) Katumani B	Kenya
16.	Local Farmers'	Local

Entry 16 was supplied locally by each station growing the trial. The trial was grown at several locations in Ethiopia, Kenya, Uganda, Tanzania, Zambia, Malawi, Congo (Kinshasa) and Nigeria. However, no data were obtained from some locations due to crop failures.

Three replications of small experimental plots were used. A 4-row plot (2 center rows harvested) of 11 plants per row with a 2 foot spacing between rows and 1 foot spacing between plants within rows was suggested. These plot dimensions were used at most locations but not at all. A 4x4 triple lattice design was used at all locations. Data were obtained on yield in quintals per hectare (1 quintal/hectare = 0.45 bags/acre), percent stand, percent lodged plants, percent of the ears having bare tips, number of ears per 100 plants, percent diseased ears, number of days from planting to tasselling, height of the node of the top ear, and blight and rust scores.

The data received are presented in the following tables. Data from two locations in Zambia, two in Malawi and one in Nigeria are presented by individual locations. Data were received from several locations in Ethiopia, Kenya, Uganda, and Tanzania. For each of these countries a summary of the agronomic data as a mean overall locations is presented in one table and yields by individual locations is indicated wherever known. No results were received from the locations in Congo (Kinshasa). It is assumed that each reader of this report will be interested in data from different locations and combinations of locations and therefore will make his own interpretations of the results. However, a very few of the more obvious and pertinent results are indicated.

ETHIOPIA

Data were received from seven locations in Ethiopia. A summary of the agronomic data is presented in Table 29. Yields from the individual locations are shown in Table 30. Yields from Melka Werer were not included in the mean column in Table 30, because ecological conditions and yields at that location were so different from the other locations.

Hybrid 613B was outstanding in yield at most locations. The other three commercially available hybrids, SR 52, H632 and H511, all yielded more than any of the composite varieties. However, Zambia Local Composite, Jimma (Jimma) and Kitale Composite E also yielded well. Additional selection planned for these varieties could result in composite varieties equal in yield to the hybrids presently available. Late maturity and higher ear placement of H613B and Kitale Composite E and the excessive number of uncovered ear tips of H 511 were apparent from the data obtained in Ethiopia.

KENYA

A summary of the agronomic data obtained at eight locations in Kenya is presented in Table 31. Yields are shown in detail in Table 32. Mean yields are presented separately for the three locations below 6,000 feet altitude and the five locations above 6,000 feet.

Below 6,000 feet hybrids H632 and H613B were nearly equal in yield and both were clearly superior to any of the other entries. Above 6,000 feet H632, H511, SR52 and Kitale Composite E were all similar in yields; but all were somewhat lower than H613B. Ear heights averaging over two meters were recorded for Kitale Composite E. Ukiriguru Composite A and H613B. Lodging averaged over all entries and all locations was 59 percent. The factors contributing to these high lodging percentages perhaps are deserving of some study.

UGANDA

Data were received from seven locations in Uganda. These locations ranged in altitudes from approximately 3,000 feet to 4,372 feet. The data for all characters are summarized in Table 33, and yields from individual locations are shown in Table 34.

The range in yields among entries was not as great in Uganda as in some other countries. The hybrids did not show the superiority over the other varieties as was shown in Kenya and Ethiopia. However, the local farmers' maize was lowest in yield and was exceeded only slightly by the very early Katumani cross. SR52, Askari Composite and Jimma (Jimma) were highest in yield but closely followed by Ilonga Composite, H632 and H511. There was little distinction among the entries for other characters except for the early maturity of the Katumani cross and the high ear placement of Kitale Composite E. Ukiriguru Composite A and H613B.

TANZANIA

Agronomic data obtained at 14 locations in Tanzania are summarized in Table 35. Yields from the individual locations are shown in Table 36. Half of the locations where the trials were grown were at an altitude below 3,000 feet and half were above 3,000 feet.

The general pattern of yields at locations above 3,000 feet was similar to locations below 3,000 feet with only a few exceptions. H632 was the highest yielding entry on the average both above and below 3,000 feet. H613B performed better relatively at the higher altitude, although still not equal to H632. The Ilonga Composite performed relatively better at the lower altitudes and was exceeded in yield only by H632 as an average of the several locations below 3,000 feet.

ZAMBIA

Data were received from two locations in Zambia. Data from the Mount Makulu Research Station are presented in Table 37 and from Misamfu in Table 38. SR 52 was the highest yielding entry at both locations. At Mount Makulu the Zambia Local Composite yielded as well as any of the hybrids except SR 52. H632 yielded well at Mount Makulu but lodged badly. The high incidence of ears with bare tips in H511 was apparent at both locations. The yield level at Misamfu was too low to provide much meaningful information.

MALAWI

Data from the Chitedze Research Station near Lilongwe and from Bvumbwe in Malawi are presented in Tables 39 and 40. Although yields were nearly twice as high at Chitedze as at Bvumbwe, the same general pattern of yields among entries prevailed. H632, SR52 and H613B were highest in yield among the hybrids with SR 52 being somewhat earlier in flowering and lower in ear height. SR52 also had less lodging. Zambia Local Composite and Kitale Composite E performed well at both locations. Ukiriguru Composite A was outstanding at Chitedze but not at Bvumbwe.

NIGERIA

Data obtained at Mokwa, Nigeria are presented in Table 41. The high coefficient of variation for yield indicates that caution should be used in interpreting the data. However, the performance of the hybrids at this location appears to be very similar to that observed at the medium altitudes in Eastern Africa. This trial was grown also at Ibadan, Nigeria. However, most of the entries were prematurely killed by rust, *Puccinia polysora*. None of the Eastern African entries yielded as well as the Nigerian local farmer entry.

GENERAL CONCLUSIONS AND SUMMARY

The hybrids generally outyielded the composite varieties at nearly all locations. At most locations in Ethiopia and Kenya above 6,000 feet in altitude the Kenya hybrid H613B was superior in yield to all others. This is a very tall hybrid having the Ecuador 573 strain as one parent. The hybrid H511 also had its best relative performance at the higher altitudes but was equal to H613B at only a very few locations. H511 is several days earlier in flowering and much shorter in plant height than H613B, but it suffers badly from a high incidence of uncovered ear tips. H632 and SR52 were similar in yield at altitudes above 6,000 feet. Below 6,000 feet H632 appeared to have an advantage at some locations and SR 52 at others. SR 52 is a few days earlier in flowering and considerably lower in ear height than H632. At no location did the early Katumani types compare favorably with the longer season entries. Some of the composite varieties show promise of future usefulness after additional selection is completed. Askari Composite, Zambia Local Composite, Ilonga Composite, Ukiriguru Composite A and Kitale Composite E all performed creditably at some locations.

Table 29. Agronomic data obtained in Ethiopia on the 1967-68 Eastern African Maize Variety Trial (number of locations for each character in parentheses).

Variety	Yield q/ha (7)	Stand % (7)	Lodging % (5)	Bare tips % (4)	Ears per 100 plants (5)	Diseased ears % (5)	Days to tassel (5)	Ear Ht. cm (4)	Blight score (1-5) (3)	Rust score (1-5) (4)
H 632	64	82	24	25	100	17	102	144	1.2	1.6
H 613B	80	86	26	35	89	14	103	178	1.5	1.1
H 511	67	82	26	48	94	32	88	135	1.1	1.5
Kat.V x Kat.VI	34	66	25	13	89	9	78	95	0.9	1.7
Jimma (Jimma)	62	83	19	6	104	11	99	160	1.5	1.9
SR 52	69	81	24	28	90	16	98	139	1.4	1.6
Askari Comp.	47	84	28	10	85	7	97	150	2.5	2.5
Zambia Local Comp.	63	87	22	22	85	16	96	144	2.1	2.3
White Star	51	81	34	8	88	9	86	117	2.0	2.3
Ilonga Comp.	55	82	25	11	95	16	94	132	1.9	2.4
Embu Comp. I	46	79	26	11	90	7	91	128	1.7	2.3
Embu Comp.II	52	77	27	16	100	12	89	130	1.9	1.7
Ukiriguru Comp.A	58	83	22	34	90	13	98	162	1.2	1.7
Kitale Comp.E	62	80	22	26	87	18	104	177	1.1	1.5
Jimma (Alemaya)	49	85	31	20	79	18	96	147	2.0	2.3
Local Farmers'	53	79	35	13	115	11	99	152	1.1	2.2
Mean	57	81	26	20	92	14	95	143	1.6	1.9

Table 30. Yields (q/ha) obtained at seven locations (approximate altitudes in feet in parentheses) in Ethiopia on the 1967-68 Eastern African Maize Variety Trials.

Variety	Kulumsa (7200)	Alemaya (6700)	Jimma I.A.R. (5700)	Jimma G.S.A. (5700)	Awasa (5500)	Bako (5200)	Mean (Over 5000)	Melka Werer (2800)
H 632	98	72	94	54	51	57	71	19
H 613B	113	83	141	55	73	63	88	34
H 511	88	95	103	45	62	45	73	31
Kat.V x Kat.VI	56	48	53	23	0	24	34	32
Jimma (Jimma)	77	76	114	43	54	41	67	26
SR 52	66	84	110	54	77	60	75	30
Askari Comp.	48	51	84	39	43	31	49	30
Zambia Local Comp.	69	78	117	43	48	49	67	36
White Star	61	104	53	37	35	35	48	33
Ilonga Comp.	66	64	81	38	47	36	55	51
Embu Comp.I	81	66	53	43	42	23	51	15
Embu Comp.II	63	63	78	36	58	29	55	35
Ukiriguru Comp.A	80	86	59	46	67	42	63	25
Kitale Comp.E	100	83	76	46	61	51	69	21
Jimma (Alemaya)	71	65	54	39	53	41	54	19
Local Farmers'	83	63	80	41	52	24	57	25
Mean	76	74	84	43	51	41	61	29
LSD (.05)	32	29	34	15	14	18	15	24
C.V. (%)	26	24	24	21	17	27		51

Table 31. Agronomic data obtained in Kenya on the 1967-68 Eastern African Maize Variety Trial (Number of locations for each character in parentheses).

Variety	Yield q/ha (8)	Stand % (8)	Lodg-ing % (8)	Bare tips % (8)	Ears per 100 plants (8)	Diseas-ed ears % (5)	Days to tassel (5)	Ear height cm (5)	Blight score (1-5) (2)	Rust score (1-5) (3)
H 632	64	98	58	11	90	8	108	178	1.4	1.3
H 613B	71	97	53	16	84	3	108	207	1.5	1.2
H 511	55	97	64	22	85	7	94	144	1.1	1.3
Kat.V x Kat.VI	21	96	71	13	64	10	80	80	1.2	1.6
Jimma (Jimma)	33	98	61	7	64	4	110	177	1.6	2.0
SR 52	58	99	46	6	80	2	102	159	1.7	1.6
Askari Comp.	31	96	61	8	61	4	107	171	1.4	2.1
Zambia Local Comp.	44	96	57	11	66	2	105	163	1.5	1.8
White Star	28	99	66	11	55	8	92	128	1.4	2.1
Ilonga Comp.	34	97	65	10	76	5	103	160	1.9	2.2
Embu Comp.I	42	96	62	12	77	5	98	145	1.6	1.8
Embu Comp.II	40	92	58	17	75	7	94	137	1.5	1.9
Ukiriguru Comp.A	56	96	49	14	77	3	109	201	1.2	1.2
Kitale Comp.E	60	98	58	14	76	2	111	218	1.4	1.2
Jimma (Alemaya)	40	99	60	10	71	9	107	163	1.8	1.7
Local Farmers'	47	88	47	13	70	7	107	166	1.8	1.6
Mean	45	96	59	12	73	5	102	162	1.5	1.7

Table 32. Yields (q/ha) obtained at eight locations (approximate altitudes in feet in parentheses) in Kenya on the 1967-68 Eastern African Maize Variety Trials.

Variety	Busia (4000)	Embu (4800)	Kaka- mega (5200)	Mean (under) 6000)	Kitale-1 (6200)	Kitale-5 (6200)	Endebess (6300)	Eldoret (7000)	Njoro (7100)	Mean (over 6000)
H 632	68	78	99	82	53	71	44	56	43	53
H 613B	70	108	78	85	49	74	70	46	76	63
H 511	53	57	42	50	60	72	57	38	58	57
Kat.V x Kat.VI	24	16	13	18	25	22	25	17	26	23
Jimma (Jimma)	56	58	31	48	27	11	31	37	15	24
SR 52	62	78	58	66	66	52	65	46	36	53
Askari Comp.	62	30	32	41	26	19	27	21	27	24
Zambia Local Comp.	57	69	33	53	58	32	42	34	30	39
White Star	43	39	15	32	22	17	21	29	36	25
Ilonga Comp.	55	48	26	43	42	18	31	34	15	28
Embu Comp.I	56	60	30	49	47	30	40	37	34	38
Embu Comp.II	49	39	27	38	42	40	42	38	41	40
Ukiriguru Comp.A	63	87	60	70	31	68	48	45	48	48
Kitale Comp.E	62	85	59	69	50	64	45	62	50	54
Jimma (Alemaya)	60	43	29	44	44	42	36	36	29	37
Local Farmers'	44	50	39	45	46	57	48	42	50	49
Mean	55	59	42	52	43	43	42	39	38	41
LSD (.05)	11.8	19.2	19.8	18.7	17.3	14.2	11.2	19.0	14.4	12.1
C.V. (%)	13.1	19.9	28.8		24.8	20.2	16.3	30.2	23.1	

Table 33. Agronomic data obtained in Uganda on the 1967-68 Eastern African Maize Variety Trial (number of locations for each character in parentheses).

Variety	Yield q/ha (7)	Stand % (7)	Lodging % (7)	Bare tips % (6)	Ears per 100 plants (6)	Diseased ears % (6)	Days to tassel (5)	Ear height cm (6)
H 632	55	93	30	32	69	12	67	189
H 613B	52	94	31	26	67	6	67	212
H 511	54	94	28	32	62	10	64	160
Kat.V x Kat.VI	41	94	26	29	68	12	51	155
Jimma (Jimma)	58	92	26	24	77	11	66	192
SR 52	60	95	20	34	69	10	64	162
Askari Comp.	69	97	22	20	83	6	67	185
Zambia Local Comp.	50	94	30	41	59	10	66	182
White Star	48	95	36	18	73	11	59	153
Ilonga Comp.	55	94	23	19	88	9	65	176
Embu Comp.I	51	92	32	25	74	12	65	172
Embu Comp.II	53	93	30	24	73	8	61	170
Ukiriguru Comp.A	44	91	27	37	62	15	68	211
Kitale Comp.E	46	92	27	41	60	11	69	221
Jimma (Alemaya)	52	96	22	27	65	9	66	178
Local Farmers'	38	92	28	21	67	11	63	152
Mean	51	94	27	28	70	10	64	179

Table 34. Yields (q/ha) obtained at seven locations (approximate altitudes in feet in parentheses) in Uganda on the 1967-68 Eastern African Maize Variety Trial

Variety	Aduku (3000)	Abi (3500)	Serere (3600)	Mubuku (3800)	Bukalasa (3900)	Bulindi (4000)	Kamenyamiggo (4372)	Mean
H 632	66	41	92	44	50	56	40	55
H613B	55	53	79	33	37	70	34	52
H 511	63	52	83	41	49	48	41	54
Kat.V x Kat.VI	53	35	58	41	33	37	30	41
Jimma (Jimma)	64	60	76	56	56	63	34	58
SR 52	83	59	76	52	61	52	36	60
Askari Comp.	59	56	70	44	59	81	43	59
Zambia Local Comp.	65	52	96	33	45	33	25	50
White Star	59	33	59	44	46	44	47	48
Ilonga Comp.	57	49	74	44	45	81	38	55
Embu Comp.I	63	49	81	44	51	44	24	51
Embu Comp.II	58	60	74	44	46	41	47	53
Ukiriguru Comp.A	59	47	55	37	50	33	29	44
Kitale Comp.E	60	58	60	30	40	44	31	46
Jimma (Alemaya)	55	36	78	30	41	89	32	52
Local Farmers'	48	46	35	33	37	33	34	38
Mean	61	49	72	41	46	53	35	51
LSD (.05)	14.3	24.3	16.6	14.6	21.3	31.4	11.5	10.6
C.V. (%)	14.5	30.4	14.2	21.9	28.1	36.1	20.1	

Table 35. Agronomic data obtained in Tanzania on the 1967-68 Eastern African Maize Variety Trial (number of locations for each character in parentheses).

Variety	Yield q/ha (14)	Stand % (14)	Lodging % (12)	Bare tips % (7)	Ears per 100 plants (12)	Diseased ears % (7)	Days to tassel (8)	Ear ht. cm (8)	Blight score (1-5) (7)	Rust score (1-5) (7)
H 632	48	85	25	17	99	15	78	125	0.7	1.8
H 613B	45	85	26	29	93	15	79	159	0.9	1.4
H 511	39	84	22	39	93	25	67	107	1.2	2.2
Kat.V x Kat.VI	24	73	41	27	85	18	57	76	1.5	2.2
LH 11	39	79	22	12	92	15	77	126	1.4	1.6
SR 52	39	76	17	23	99	14	78	150	1.6	2.0
Askari Comp.	40	88	23	11	92	13	75	133	1.9	2.2
Zambia Local Comp.	37	81	17	25	80	18	76	122	1.4	2.0
White Star	30	86	31	15	87	15	68	103	1.7	1.9
Ilonga Comp.	40	85	18	17	101	10	74	137	2.1	1.9
Embu Comp.I	37	87	30	17	91	17	70	113	1.7	1.8
Embu Comp.II	34	78	25	22	95	15	70	110	1.8	2.0
Ukiriguru Comp.A	40	84	21	16	83	12	79	155	1.1	1.6
Kitale Comp.E	40	83	24	19	83	15	78	169	1.1	1.6
Katumani Comp.B	23	80	37	24	85	22	59	78	1.8	2.4
Local Farmers'	35	84	19	12	91	9	72	113	1.4	1.8
Mean	37	82	25	20	91	16	72	123	1.4	1.9

Table 36. Yields (q/ha) obtained at fourteen locations (approximate altitudes in feet in parentheses) in Tanzania on the 1967-68 Eastern African Maize Variety Trials.

Variety	Bwembwera (700)	Wami (1500)	Illonga (1650)	Korogwe (2000)	Handeni (2000)	Morogoro (2000)	Moshi (2800)	Mean (under 3000)
H 632	46	17	46	50	53	33	78	46
H 613B	41	13	25	52	52	39	75	42
H 511	37	22	24	44	46	24	60	37
Kat.V x Kat.VI	22	16	16	28	25	21	28	22
LH 11	45	20	29	47	44	33	69	41
SR 52	37	19	30	27	54	44	63	39
Askari Comp.	39	20	40	49	38	41	65	42
Zambia Local Comp.	28	12	35	42	46	27	57	35
White Star	32	12	22	47	32	24	57	32
Ilonga Comp.	42	27	39	47	46	38	63	43
Embu Comp.I	44	14	28	44	42	32	68	39
Embu Comp.II	36	17	26	39	40	27	47	33
Ukiriguru Comp.A	32	16	34	34	41	32	70	37
Kitale Comp.E	29	14	26	39	44	34	74	37
Katumani Comp.B	22	16	12	20	33	23	33	23
Local Farmers'	32	15	30	39	40	23	46	32
Mean	35	17	29	41	42	31	60	36
LSD (.05)	9	6	9	12	13	8	15	7.0
C.V. (%)	16	20	19	18	18	16	15	

Table 36 (continued)

Variety	Urambo (3700)	Ukiriguru (3900)	Arusha (4000)	Ismani (4000)	Bwanga (4000)	Tarime (5900)	Njombe (6500)	Mean (over 3000)
H 632	41	66	25	77	16	64	60	50
H 613B	57	64	30	57	14	73	36	47
H 511	48	51	29	53	18	36	53	41
Kat.V x Kat.VI	31	51	15	32	12	7	37	26
LH 11	53	67	29	51	9	29	21	37
SR52	49	60	24	40	16	49	40	40
Askari Comp.	57	71	27	46	10	23	31	38
Zambia Local Comp.	53	57	21	58	7	23	51	39
White Star	31	53	19	38	6	22	30	28
Ilonga Comp.	59	64	27	44	10	24	37	38
Embu Comp. I	45	70	23	44	13	24	36	36
Embu Comp.II	47	60	23	45	14	20	38	35
Ukiriguru Comp.A	30	74	30	62	14	54	44	44
Kitale CompE.	35	58	33	59	12	53	52	43
Katumani Comp.B	34	37	17	33	11	13	26	24
Local Farmers'	38	60	26	47	6	43	50	39
Mean	44	60	25	49	12	35	40	38
LSD (.05)	22	22	8	9	7	17	12	10.4
C.V. (%)	31	22	19	11	34	30	18	

Table 37. Agronomic data obtained at the Mount Makulu Research Station, Zambia on the 1967-68 Eastern African Maize Variety Trial.

Variety	Yield* q/ha	Stand %	Lodg-ing %	Bare tips %	Ears per 100 plants	Diseased ears %	Days to tassel	Ear ht. cm.	Blight Score (0-5)	Rust Score (0-5)
H 632	66	79	48	15	130	0	75	152	0.2	0.3
H 613B	59	80	16	16	112	2	80	205	0.0	0.3
H 511	60	80	21	43	106	0	69	142	0.3	0.2
Kat.V x Kat.VI	43	82	15	25	96	2	59	92	0.5	0.2
LH 11	61	67	4	9	129	0	79	170	0.5	0.8
SR 52	72	80	4	20	109	0	71	145	0.3	0.2
Askari Comp.	49	52	3	6	121	0	73	159	0.2	0.8
Zambia Local Comp.	65	71	4	18	118	0	72	152	0.5	0.5
White Star	48	67	43	10	117	0	67	114	1.0	0.5
Ilonga Comp.	57	68	30	7	159	0	73	158	0.8	2.0
Embu Comp.I	55	77	41	8	116	0	72	153	0.2	0.8
Embu Comp.II	52	49	16	15	151	0	71	124	0.5	0.8
Ukiriguru Comp.A	57	80	20	8	119	0	80	192	0.3	0.0
Kitale Comp.E	49	79	28	13	121	0	81	219	0.2	0.5
Katumani Comp.B	46	74	32	16	119	0	60	95	0.5	0.2
Local Farmers'	56	76	6	8	108	2	71	136	0.5	1.3
Mean	56	73	21	15	121	0	72	151	0.4	0.6
LSD (.05)	10									
C.V. (%)	11									

*Yields were adjusted for stand differences by covariance analysis

Table 38. Agronomic data obtained at Misamfu, Zambia on the 1967-68 Eastern African Maize Variety Trial.

Variety	Yield q/ha	Stand %	Lodging %	Bare tips %	Ears per 100 plants	Diseased ears %	Days to tassel	Ear ht. cm	Blight score (0-5)	Rust score (0-5)
H 632	8	100	2	0	20	30	96	68	1.2	0
H 613B	13	99	6	0	37	23	97	99	1.5	0
H 511	10	99	20	19	44	38	82	62	2.0	0
Kat.V x Kat.VI	9	94	15	5	42	48	71	39	0.8	0
LH 11	8	100	0	5	29	26	96	64	1.7	0.2
SR 52	20	100	2	3	62	27	87	82	0.7	0
Askari Comp.	10	99	5	0	33	28	97	74	0.7	0.2
Zambia Local Comp.	14	100	8	21	39	30	88	80	2.0	0
White Star	9	97	3	8	34	43	83	65	3.3	0
Ilonga Comp.	15	100	6	2	61	26	88	78	3.0	0
Embu Comp. I	8	97	15	20	37	42	86	58	2.3	0
Embu Comp.II	5	56	9	18	36	44	85	40	2.0	0
Ukiriguru Comp.A	11	100	3	30	24	39	96	93	0.8	0
Kitale Comp.E	10	96	6	29	32	33	97	112	1.0	0.2
Katumani Comp.B	10	97	16	20	50	34	71	42	0.7	0
Local Farmers'	6	100	6	23	24	32	85	60	3.7	0
Mean	10	96	8	13	38	39	88	70	1.7	0
LSD	9									
C.V. (%)	54									

Table 39. Agronomic data obtained at Chitedze Research Station, Malawi on the 1967-68 Eastern African Maize Variety Trial

Variety	Yield q/ha	Stand %	Lodging %	Bare tips %	Ears per 100 plants	Diseased ears %	Days to tassel	Ear ht. cm	Blight score (0-5)	Rust score (0-5)
H 632	73	96	24	41	116	2	77	170	0.1	0.7
H 613B	72	97	22	35	100	3	82	222	0	0.3
H 511	60	89	46	51	111	0	75	140	0	0.4
Kat.V x Kat.VI	40	91	28	10	105	0	61	99	0.1	0.6
LH 11	64	92	40	18	104	5	78	182	0.2	1.9
SR 52	73	94	10	54	105	2	75	160	0.2	1.6
Askari Comp.	56	89	22	18	107	0	78	169	0.4	2.6
Zambia Local Comp.	68	92	30	41	92	3	77	183	0.3	1.9
White Star	48	96	37	31	89	6	67	143	0.4	1.8
Ilonga Comp.	56	96	71	29	109	2	74	175	0.3	2.6
Embu Comp.I	60	91	33	29	115	2	74	151	0.4	2.1
Embu Comp.II	45	71	41	21	112	2	74	149	0.2	1.5
Ukiriguru Comp.A	75	100	23	23	100	2	82	213	0	0.7
Kitale Comp.E	71	99	17	34	100	0	84	238	0.2	0.3
Katumani Comp.B	51	94	47	30	107	0	60	104	0.2	1.0
Local Farmers'	31	94	43	2	79	3	81	190	0.6	3.0
Mean	59	93	33	29	103	2	75	168	0.2	1.4
LSD (.05)	9									
C.V. (%)	10									

Table 40. Agronomic data obtained at Bvumbwe, Malawi on the 1967-68 Eastern African Maize Variety Trial.

Variety	Yield q/ha	Stand %	Lodging %	Bare tips %	Ears per 100 plants	Diseased ears %	Days to tassel
H 632	41	100	39	48	59	12	75
H 613B	36	99	28	45	48	8	80
H 511	35	99	31	56	52	5	70
Kat.V x Kat.VI	23	100	26	64	41	9	55
LH 11	42	97	30	52	52	13	70
SR 52	36	100	14	68	44	12	70
Askari Comp.	19	100	12	81	30	11	75
Zambia Local Comp.	32	100	39	46	49	8	80
White Star	24	100	27	71	46	6	65
Ilonga Comp.	28	100	18	68	49	11	75
Embu Comp.I	19	86	25	78	47	16	80
Embu Comp.II	28	80	29	49	56	3	70
Ukiriguru Comp.A	24	100	29	63	41	11	80
Kitale Comp.E	33	100	32	82	39	18	84
Katumani Comp.B.	26	100	36	42	55	6	55
Local Farmers'	25	100	8	11	56	2	75
Mean	29	98	26	58	48	9	72
LSD	12						
C.V. (%)	25						

Table 41. Agronomic data obtained at Mokwa, Nigeria on the 1967-68 Eastern African Maize Variety Trial.

Variety	Yield q/ha	Stand %	Lodging %	Bare tips %	Ears per 100 plants	Diseases ears %	Days to tassel	Ear ht. cm	Blight score (0-5)	Rust score (0-5)
H 632	38	88	25	29	84	12	58	130	1.3	1.0
H 613B	34	92	35	16	81	12	62	176	1.0	1.0
H 511	29	86	23	23	85	9	54	128	1.0	1.0
Kat.V x Kat.VI	19	79	8	27	85	4	55	75	1.3	0
Jimma (Jimma)	26	89	16	25	78	2	60	126	1.0	1.0
SR 52	40	80	12	17	105	0	55	97	2.0	1.0
Askari Comp.	27	83	24	10	88	0	61	130	1.0	1.0
Zambia Local Comp.	22	80	5	22	80	5	58	111	1.7	1.0
White Star	27	82	33	10	83	10	53	99	1.7	1.0
Ilonga Comp.	22	65	16	19	98	5	54	112	1.0	0.3
Embu Comp.I	39	74	23	10	101	16	52	122	1.0	0.7
Embu CompII	23	55	31	24	89	11	55	105	1.0	1.0
Ukiriguru Comp.A	23	94	21	32	74	3	61	156	1.0	1.0
Kitale Comp.E	15	83	27	34	65	2	63	145	1.0	0.7
Jimma (Alemaya)	24	88	17	11	68	4	56	125	1.7	1.0
Local Farmers'	28	61	36	10	121	6	58	139	1.7	1.3
Mean	27	80	22	20	87	6	57	123	1.3	0.9
LSD	15									
C.V. (%)	33									

1968-69 Eastern African Maize Variety Trial

Lowell H. Penny

The 1968-69 Eastern African Maize Variety Trial consisted of 25 entries grown at several locations in most of the countries of Eastern Africa. Data from only part of the locations are available at this time. A complete report of these trials will be made when data are received from all the locations in all countries.

A summary of the agronomic data from the seven Kenya locations is presented in Table 42 and yields for each Kenya location are presented in Table 43. H611(R)C1 was outstanding in yield at all locations in Kenya and especially at the higher altitudes. The yield of the composite cross KCB x KCE also was encouraging, being exceeded only by H611(R)C1 and H613B as an average of the four high altitude locations. This particular composite cross is the basis for the present Kenya applied breeding program for the high altitudes of Western Kenya. As selection continues in the two parental composite varieties, the cross is expected soon to become superior to H611B, H613B, and H632; and commercial production will then be started.

Table 42. Agronomic data obtained in the 1968-69 Eastern African Regional Maize Varietal Trials grown as Experiment 927 at seven locations in Kenya in 1969.

Entry	Yield q/ha	Stand %	Lodging %	Bare tips per 100 plants	Usable ears per 100 plants	Diseased ears %	Days to tassel	Ear ht. cm	Rust score (1-5)
H632	68.7	98.0	50.4	6.4	91.3	5.5	89.5	197.4	1.5
H 613B	69.9	95.8	41.2	20.9	82.3	3.5	90.9	220.3	1.2
H 511	41.0	96.4	49.4	21.3	70.8	11.0	77.2	164.4	1.5
SR 52	55.7	97.2	34.5	6.8	80.8	2.9	81.3	178.0	2.4
UCB-W x UCA	58.3	99.0	38.8	13.4	82.0	5.1	86.7	195.4	1.6
H 611(R)C1	83.2	97.3	29.9	8.9	91.1	0.5	91.4	235.4	1.1
KCB x KCC	66.0	98.3	31.6	21.4	78.7	5.0	91.1	225.4	1.3
SR52 x 63J96	51.4	96.9	40.8	9.1	78.6	3.3	86.6	175.5	2.3
SR52 x 63J347	59.5	97.4	41.0	8.3	80.7	3.4	84.3	183.6	2.4
ZCA x UCA	54.9	91.8	27.0	12.4	75.1	4.7	87.2	192.9	1.8
ZCA x KCC	56.4	93.4	35.8	13.8	76.3	6.6	88.6	203.8	1.4
ZCA x IC	45.9	99.1	42.2	11.2	73.4	5.1	82.5	177.0	2.7
KCB x UCA	61.6	98.8	30.4	17.6	77.8	4.3	89.2	209.7	1.4
KCB x IC	57.8	98.4	30.9	15.4	85.9	4.4	86.0	205.8	1.3
KCB x KCE	69.9	99.6	35.4	16.3	81.2	3.0	89.6	220.9	1.2
Kawanda Comp.A	58.9	97.5	43.8	10.7	80.1	4.5	85.5	198.2	1.5
Ukiriguru Comp.B-W	52.3	98.6	55.6	9.1	81.9	7.1	85.3	183.4	2.4
Kitale Comp.B	55.2	98.6	30.4	19.5	67.4	3.8	88.8	208.2	1.2
Kitale Comp.C	63.0	98.0	36.9	12.0	80.9	2.2	92.8	229.3	1.3
Kitale Comp.E	59.9	96.5	35.9	14.2	76.8	2.5	93.5	235.6	1.2
Ilonga Comp.	40.5	96.8	47.3	7.7	86.2	4.7	83.9	180.5	3.1
Ukiriguru Comp.A	64.0	96/8	35.1	10.9	83.6	3.3	90.1	212.0	1.5
Zambia Comp.A	45.0	96.2	45.4	7.3	68.9	7.2	85.8	179.5	2.3
Local Synthetic	57.6	98.7	42.7	6.5	79.1	2.7	90.3	204.7	1.2
Local Farmer's	53.6	86.9	48.3	6.4	80.3	3.0	91.0	195.9	1.7
Mean	58.0	96.9	39.2	12.3	79.7	4.4	87.6	200.5	1.7

Table 43. Yields (q/ha) obtained in the 1968-69 Eastern African Regional Maize Varietal Trials grown as Experiment 927 at seven locations in Kenya in 1969.

Entry	N.A.R.S. Kitale Grass-lands	N.A.R.S. Kitale Top Farm	Endebess Strong farm	Mt.Elgon Chorlim farm	Mean over 1830m	Kakamega	Busia	Embu	Mean under 1830m
H 632	87.1	80.6	88.3	82.7	84.7	63.0	45.0	34.3	47.4
H 613B	67.3	85.3	86.1	136.9	93.9	34.2	44.0	35.5	37.9
H 511	58.4	38.5	56.1	27.8	45.2	42.6	30.0	33.8	35.5
SR 52	75.3	86.6	75.5	38.4	69.0	26.1	50.3	37.8	38.1
UCB-W x UCA	71.5	72.0	78.4	69.8	73.0	38.0	46.5	32.2	38.9
H 611(R)C1	98.2	98.8	93.7	128.9	104.9	66.2	58.2	38.3	54.2
KCB x KCC	73.8	72.2	88.2	98.1	83.1	43.0	53.1	33.7	43.3
SR52 x 63J96	75.1	66.4	66.4	39.2	61.8	33.5	46.6	32.9	37.7
SR52 x 63J347	78.7	75.0	66.8	53.7	68.6	55.9	54.6	31.9	47.5
ZCA x UCA	73.7	62.8	83.1	28.8	62.1	47.3	50.6	37.7	45.2
ZCA x KCC	71.0	70.0	79.4	63.7	71.0	30.8	45.4	34.5	36.9
ZCA x IC	50.2	50.2	53.8	40.6	48.7	58.7	36.5	31.3	42.2
KCB x UCA	71.2	70.5	85.6	85.3	78.1	40.1	42.2	36.5	39.6
KCB x IC	73.1	68.2	68.9	66.2	69.1	49.6	46.9	31.6	42.7
KCB x KCE	77.4	76.3	83.3	115.9	88.2	69.0	33.7	33.7	45.5
Kawanda Comp.A	67.5	69.0	73.0	81.0	72.6	44.5	43.7	33.8	40.7
Ukiriguru Comp.B-W	68.0	58.0	71.3	53.4	62.7	35.7	47.0	33.0	38.6
Kitale Comp.B	65.0	65.4	81.1	61.2	68.2	36.3	46.3	31.1	37.9
Kitale Comp.C	68.1	69.5	77.0	94.3	77.2	53.6	42.8	35.5	44.0
Kitale Comp.E	62.2	79.6	63.9	98.1	75.9	53.9	28.0	33.4	38.4
Ilonga Comp.	48.2	44.7	39.9	29.9	40.7	48.1	45.9	26.9	40.3
Ukiriguru Comp.A	71.2	69.9	78.0	81.8	75.2	58.8	52.0	36.0	48.9
Zambia Comp.A	58.8	49.1	59.3	32.8	50.0	40.2	39.3	35.3	38.3
Local Synthetic	56.8	70.7	68.5	82.8	69.7	54.6	40.8	29.3	41.6
Local Farmers'	50.4	71.9	62.9	94.1	69.8	19.3	43.4	33.2	32.0
Mean	68.7	68.9	73.1	71.4	70.5	45.7	44.5	33.7	41.3
LSD (.05)	15.9	15.2	13.3	29.9		29.2	18.2	6.6	
C.V. (%)	14.1	13.6	11.2	25.6		39.1	25.0	12.0	

Eastern African Variety Diallel Trials

All possible combinations of crosses among ten Eastern African Composite Varieties were produced in 1968 for yield trials in 1969. The varieties involved were Kitale Syn II (R11)C1, Ecuador 573(R12) C1, Kitale Composite A(S13)C1, Kitale Composite B(67), Kitale Composite C(S)C1, and Kitale Composite E(67) from Kenya; Ukiriguru Composite B-W, Ukiriguru Composite A, and Ilonga Composite-R from Tanzania; and Zambia Composite A. The varieties and their crosses were grown successfully as Experiment 923 at two locations in Zambia, two locations in Tanzania, and six locations in Kenya. The experiment was grown as an 8 x 8 triple lattice at each location. A summary of the agronomic data obtained in Kenya is presented in Table 44. Yields obtained at each location are presented in Table 45. The last ten entries in the experiment were hybrids included as standards for comparison and were somewhat different in Kenya than in Zambia and Tanzania. The yields of the varieties and variety crosses are summarized in a more condensed form in Tables 46 to 48.

The performance of Ec.573 in these crosses is interesting. In the high altitude areas of Kenya it had the highest average yields in crosses. In both Tanzania and Zambia its average yields in crosses were not good, but it was one parent in the highest yielding individual cross in each country - EC573(R12)C1 x UCB-W in Tanzania and Ec.573 (R12)C1 x ZCA in Zambia. Crosses involving KII(R11)C1 performed well in all countries. Crosses of ZCA yielded very poorly in Kenya but very well in Zambia and above average in Tanzania.

Table 44. Agronomic data obtained on composite varieties and varietal crosses grown as Experiment 923 at six locations in Kenya in 1969.

Entry	yield q/ha.	Stand %	Lodging %	Bare Tips per 100 plants	Usable ears per 100 plants	Diseased ears	Days to tassel	Ear height
Kitale II(R11)C1	57.2	95.5	49.4	5.9	78.0	8.2	95.3	212.5
Ec573(R12)C1	39.2	91.2	52.6	5.8	72.1	4.9	100.6	232.0
Kitale Comp.A(S13)C1	56.2	98.2	49.2	16.7	71.7	5.3	95.5	229.1
Kitale Comp.B(67)	57.4	98.2	45.5	22.0	65.8	3.9	89.0	207.0
Kitale Comp.C(S)C1	57.0	95.5	54.5	11.7	66.8	2.4	96.2	231.7
Kitale Comp.E(67)	59.0	97.7	53.5	18.4	66.6	4.5	96.4	232.4
Ukiriguru Comp.B-W	54.2	98.5	68.4	9.4	81.4	3.6	88.1	191.9
Ukiriguru Comp.A	59.0	98.0	56.3	14.0	72.6	3.4	92.3	214.6
Zambia Comp.A	34.9	98.5	58.5	8.3	51.2	4.2	87.7	177.2
Ilonga Comp.-R	34.5	96.0	61.8	11.8	68.9	5.7	86.5	184.2
KII x Ec573	74.6	97.0	53.4	14.8	82.3	3.6	94.7	231.1
KII x KCA	74.6	96.7	47.3	15.4	84.5	5.2	95.3	222.2
KII x KCB	67.6	96.7	43.6	14.4	76.5	4.5	92.5	213.2
KII x KCC	73.9	97.2	48.3	10.7	84.8	1.3	95.0	232.3
KII x KCE	65.3	98.2	59.6	18.2	74.7	6.9	94.9	229.4
KII x UCB-W	62.7	97.2	62.3	8.0	83.2	5.5	92.2	205.3
KII x UCA	65.9	98.5	52.7	14.3	80.3	6.0	93.2	217.3
KII x ZCA	62.1	97.2	54.3	9.3	81.5	6.1	88.9	189.1
KII x IC-R	58.5	98.7	53.2	5.3	82.2	3.8	89.3	205.3
Ec573 x KCA	61.0	96.2	38.0	8.3	75.8	2.8	94.4	232.3
Ec573 x KCB	72.0	97.2	47.1	11.6	77.2	3.1	94.7	234.7
x KCC	69.8	99.0	48.5	15.4	78.0	3.0	94.7	243.7
x KCE	65.9	97.2	46.4	18.9	75.8	3.4	95.2	241.6
x UCB-W	73.3	96.5	56.0	5.6	83.8	5.2	92.5	228.1
x UCA	71.8	96.7	49.6	10.7	80.9	2.7	93.2	221.5

Table 44 (continued)

Entry	Yield %	Stand %	Lodging %	Bare tips per 100 plants	Usable ears per 100 plants	Diseased ears	Days to tassel	Ear ht.
Ec573 x ZCA	72.9	97.7	41.4	13.4	81.5	4.9	91.0	214.4
x IC-R	73.9	98.2	41.1	7.0	91.9	3.3	89.5	217.7
KCA x KCB	69.9	98.0	47.1	16.8	75.5	3.5	91.1	227.8
x KCC	65.9	98.5	51.8	18.9	75.7	1.8	94.7	234.2
x KCE	68.3	98.7	51.9	16.1	80.1	2.6	94.6	231.8
x UCB-W	64.5	98.2	55.6	13.7	77.9	3.9	88.9	210.1
x UCA	67.9	98.5	50.0	16.5	77.3	6.2	92.9	217.4
x ZCA	57.2	98.5	50.2	13.0	67.3	5.9	89.3	202.3
x IC-R	64.8	96.0	64.0	12.2	80.2	3.4	88.0	208.7
KCB x KCC	63.2	96.7	48.4	25.6	68.6	5.5	91.9	226.8
x KCE	63.7	99.0	52.5	19.3	69.9	4.6	92.5	226.9
x UCB-W	64.6	98.7	53.9	13.1	79.1	1.8	87.7	204.5
x UCA	61.6	99.2	49.0	18.0	70.2	6.1	89.6	209.6
x ZCA	62.4	96.5	49.5	20.5	71.7	5.5	87.4	199.6
x IC-R	64.0	95.2	47.2	19.2	84.7	3.5	86.5	209.2
KCC x KCE	59.8	97.5	58.7	18.9	66.0	2.3	95.5	234.7
x UCB-W	57.9	98.5	54.9	16.2	69.8	4.1	90.7	208.2
x UCA	60.6	98.7	48.2	27.4	71.0	6.7	92.3	217.2
x ZCA	56.1	93.2	53.4	17.7	70.4	5.8	90.2	208.4
x IC-R	59.1	99.2	53.3	15.0	77.4	4.8	87.2	215.0
KCE x UCB-W	58.4	96.5	55.4	9.0	76.6	6.5	91.4	203.3
x UCA	61.6	98.0	47.9	19.9	71.5	4.6	92.5	218.8
x ZCA	58.3	98.5	53.4	14.4	70.5	4.9	90.2	207.2
x IC-R	60.9	97.7	56.1	12.9	81.8	5.0	89.5	216.1
UCB-W x UCA	57.8	98.5	50.9	10.5	77.5	5.1	87.4	194.4

Table 44 (continued)

Entry	Yield q/ha	Stand %	Lodging %	Bare tips per 100 plants	Usable ears per 100 plants	Diseased ears	Days to tassel	Ear height
UCB-W x ZCA	45.1	96.5	62.4	10.6	67.3	5.5	86.6	181.0
x IC-R	40.8	96.0	58.2	5.4	73.5	5.8	84.7	182.4
UCA x ZCA	46.7	72.5	49.6	16.4	71.9	6.8	88.6	193.9
x IC-R	55.2	97.7	46.2	16.9	78.2	7.1	87.2	197.2
ZCA x IC-R	42.1	96.5	55.2	5.4	67.5	4.7	84.8	178.4
H 632	64.1	92.2	63.5	7.5	84.3	7.0	90.2	199.0
SR 52	55.0	97.7	52.8	5.5	76.9	2.9	84.2	172.9
H 613B	69.5	93.7	58.0	32.4	83.4	4.1	93.8	226.3
H 611B	74.0	93.7	49.6	22.8	76.9	2.9	95.3	244.0
H 613 CO	73.1	97.5	62.0	22.6	83.1	4.6	94.6	232.0
H 613(R)C1	55.5	82.1	52.0	16.2	68.7	5.2	92.6	222.2
H 613(R)C2	81.1	98.7	49.8	18.1	91.0	3.8	92.9	221.2
H 611 CO	68.0	94.7	55.8	16.0	75.1	3.8	94.4	239.5
H 611(R)C1	74.6	97.0	53.4	14.8	82.3	3.6	94.7	231.1
H 611(R)C2	80.1	96.5	41.1	6.8	86.2	2.5	93.2	227.0
Mean	61.8	96.5	52.4	14.3	76.0	4.5	91.5	214.7
LSD(.05)	12.1	4.6	13.0	7.9	11.2	3.9	2.4	11.6

Table 45. Yields (q/ha) of composite varieties and varietal crosses grown as Experiment 923 at six locations in Kenya, two in Zambia, and two in Tanzania.

	Location									
	Kenya						Zambia		Tanzania	
Entry	05	02	03	01	07	45	24	26	95	97
Kitale II (R11)C1	65.2	78.0	21.7	76.1	77.7	24.4	40.8	15.0	39.5	18.3
EC573(R12)C1	46.1	44.7	13.9	54.6	60.2	15.9	4.8	11.7	15.6	8.7
Kitale Comp.A(S13)C1	66.4	73.2	33.8	51.4	83.6	28.6	52.4	13.4	20.9	18.4
Kitale Comp.B(67)	64.6	79.7	32.3	57.9	89.0	20.8	46.1	35.2	31.3	26.6
Kitale Comp.C(S)C1	70.6	88.1	15.3	73.3	71.6	23.4	32.8	24.8	25.4	19.7
Kitale Comp.E(67)	69.0	80.1	18.4	74.1	68.9	43.8	47.3	33.2	28.7	21.8
Ukiriguru Comp.B-W	60.5	71.1	36.5	60.3	57.2	39.5	46.3	36.5	44.0	22.7
Ukiriguru Comp.A	59.3	86.2	35.2	58.3	73.3	41.7	50.6	29.6	31.7	24.8
Zambia Comp.A	39.7	30.3	16.6	54.9	41.7	26.5	54.8	21.5	37.0	20.2
Ilonga Comp.-R	37.8	38.5	14.9	47.8	28.2	40.0	43.8	26.7	26.2	18.1
KII x Ec573	78.5	88.4	44.0	66.3	128.2	42.1	59.4	47.2	31.7	27.4
x KCA	69.2	103.5	27.6	94.3	122.1	30.6	57.1	25.4	36.3	23.4
x KCB	79.2	87.3	40.2	79.5	85.8	33.4	69.9	18.6	42.2	17.6
x KCC	82.5	101.5	32.2	75.3	118.8	33.3	79.8	38.4	50.2	26.5
x KCE	79.9	93.5	25.7	60.6	100.4	31.9	66.6	25.4	25.8	22.4
x UCB-W	66.7	78.8	32.1	69.9	82.3	46.3	49.4	30.3	46.4	18.0
x UCA	67.8	91.8	33.4	78.0	83.0	41.4	66.0	44.9	43.8	30.9
x ZCA	82.2	71.6	33.0	81.0	64.6	40.4	69.2	46.9	44.0	21.0
x IC-R	62.7	68.1	42.2	67.7	58.3	51.9	59.5	28.7	41.1	32.4
Ec573 x KCA	71.3	67.9	34.0	77.7	88.9	25.9	38.7	27.0	32.7	11.4
x KCB	81.4	93.2	39.9	91.6	89.5	36.4	39.8	32.2	41.6	21.0
x KCC	81.9	80.1	33.8	78.5	111.1	33.0	43.7	41.7	30.9	13.9
x KCE	82.5	87.7	29.3	70.8	97.2	27.8	38.6	30.9	27.1	21.5
x UCB-W	80.2	92.0	47.9	83.5	95.3	41.1	68.7	23.1	50.6	30.8
x UCA	87.4	91.2	37.2	73.4	95.9	45.5	63.9	35.2	34.9	17.6

Table 45. (continued)

	Location									
	Kenya						Zambia		Tanzania	
Entry	05	02	03	01	07	45	24	26	95	97
Ec573 x ZCA	89.1	95.0	42.1	71.2	103.9	36.0	78.2	55.4	34.3	29.5
x IC-R	77.5	87.8	55.3	96.9	86.6	39.1	65.8	31.6	42.4	24.3
KCA x KCB	83.5	71.4	50.4	78.4	100.7	35.0	67.2	30.6	34.9	24.0
x KCC	67.9	78.2	44.1	64.8	101.3	39.0	59.7	27.7	46.4	15.7
x KCE	78.6	85.6	46.8	73.8	92.6	32.7	43.0	20.5	36.8	16.3
x UCB-W	64.6	80.2	50.3	62.8	85.4	43.6	54.7	24.8	43.1	19.9
x UCA	78.8	77.0	42.3	70.2	100.2	38.6	50.4	30.3	33.0	15.9
x ZCA	63.0	68.0	33.1	64.0	79.1	36.2	59.6	27.4	44.3	30.0
x IC-R	73.4	74.7	47.9	72.7	77.1	42.9	64.8	40.4	38.9	9.7
KCB x KCC	69.5	85.2	35.8	60.9	101.6	26.0	60.5	28.0	29.6	27.2
x KCE	69.7	78.6	38.1	72.7	90.9	31.9	62.3	32.6	30.6	18.5
x UCB-W	78.7	78.5	44.1	74.0	67.0	45.0	69.6	31.9	33.7	22.1
x UCA	62.6	81.6	37.5	67.9	86.1	34.2	69.8	34.8	42.8	16.1
x ZCA	72.4	78.0	32.6	66.9	81.2	43.6	67.1	43.6	31.8	28.0
x IC-R	70.4	74.3	50.8	63.4	74.1	50.9	56.2	22.1	39.4	25.8
KCC x KCE	73.0	77.7	18.7	61.3	88.0	40.4	34.8	28.0	23.9	17.4
x UCB-W	68.4	82.5	27.8	58.0	70.4	40.3	62.0	27.0	40.9	25.2
x UCA	66.4	85.7	32.4	62.0	93.5	23.7	86.8	30.0	36.6	22.5
x ZCA	68.0	82.7	24.7	53.2	72.6	35.4	61.4	28.3	31.1	27.3
x IC-R	64.0	79.8	49.7	62.7	64.0	34.7	63.8	41.4	41.1	25.4
KCE x UCB-W	74.4	74.7	30.2	50.5	78.3	42.0	68.1	21.5	35.2	19.8
x UCA	77.7	77.3	28.1	64.8	78.2	43.5	62.9	36.8	41.9	22.6
x ZCA	69.1	77.4	38.0	68.2	57.1	40.2	69.1	28.3	35.2	25.7
x IC-R	70.7	77.6	40.2	56.3	75.2	45.3	59.9	39.1	39.5	25.3
UCB-W x UCA	65.2	72.9	33.8	56.1	78.0	40.5	42.7	32.2	39.1	24.9

Table 45. (Continued)

Entry	Location									
	Kenya						Zambia		Tanzania	
	05	02	03	01	07	45	24	26	95	97
UCB-W x ZCA	48.8	52.8	34.4	58.6	44.1	32.0	55.6	34.5	37.8	26.7
x IC-R	40.9	48.8	23.4	59.2	28.9	43.8	39.0	37.5	35.7	15.6
UCA x ZCA	53.4	57.2	36.0	51.8	56.6	25.4	51.8	27.4	40.3	25.9
x IC-R	59.3	69.1	31.1	51.0	72.0	48.3	50.2	42.7	38.5	17.9
ZCA x IC-R	55.3	43.6	15.1	54.5	37.7	46.4	54.6	33.2	36.8	13.7
H 632	76.7	95.5	36.3	65.3	76.1	34.6	70.9	49.2	53.4	32.2
H 632							52.9	42.7	66.9	28.3
SR 52	66.7	62.8	38.0	72.2	48.1	42.1	51.6	57.0	58.9	31.1
SR 52							68.5	50.2	33.4	22.4
H 613B	95.2	101.1	28.9	71.9	80.2	39.4	62.4	47.2	46.1	28.4
H 613B							59.3	67.1	42.4	25.4
H 611B	85.4	92.6	30.5	87.2	112.7	35.3	75.5	45.6	44.1	18.7
H 611B							55.3	32.6	37.6	22.9
H 611B							63.8	52.4	26.0	30.1
H 613(R)C0	80.8	109.2	51.0	69.6	86.6	41.4				
H 613(R)C1	61.6	77.8	28.2	55.8	76.9	32.9				
H 613(R)C2	83.7	101.8	49.2	87.3	114.6	49.9				
H 611(R)CO	69.8	83.7	35.0	81.0	100.2	38.3				
H 611 (R)C1	78.5	88.4	44.0	66.3	128.2	42.1				
H 611 (R)C2	95.2	97.0	67.6	82.2	103.5	35.2				
Mean	70.3	78.8	35.2	68.1	81.2	37.1	56.9	33.7	37.6	22.4
LSD (.05)	18.1	13.9	17.4	19.2	22.8	16.1	22.3	24.5	18.2	14.3
C.V.(%)	15.7	10.8	30.4	17.2	17.2	26.6	24.0	44.5	29.6	39.2

Table 46. Yields (q/ha) of varieties and varietal crosses grown as Experiment 923 at six locations in Kenya in 1969

Variety	KII(R11)C1	Ec573(R12)C1	KCA(S13)C1	KCB(67)	KCC(S)C1	KCE(67)	UCB-W	UCA	ZCA	IC-R	Variety
KII(R11)C1		74.6	74.6	67.6	73.9	65.3	62.7	65.9	62.1	58.5	57.2
Ec573(R12)C1	74.6		61.0	72.0	69.8	65.9	73.3	71.8	72.9	73.9	39.2
KCA(S13)C1	74.6	61.0		69.6	65.9	68.3	64.5	67.9	57.2	64.8	56.2
KCB(67)	67.6	72.0	69.9		63.2	63.7	64.6	61.6	62.4	64.0	57.4
KCC(S)C1	73.9	69.8	65.9	63.2		59.8	57.9	60.6	56.1	59.1	57.0
KCE(67)	65.3	65.9	68.3	63.7	59.8		58.4	61.6	58.3	60.9	59.0
UCB-W	62.7	73.3	64.5	64.6	57.9	58.4		57.8	45.1	40.8	54.2
UCA	65.9	71.8	67.9	61.6	60.6	61.6	57.8		46.7	55.2	59.0
ZCA	62.1	72.9	57.2	62.4	56.1	58.3	45.1	46.7		42.1	34.9
IC-R	58.5	73.9	64.8	64.0	59.1	60.9	40.8	55.2	42.1		34.5
Mean	67.2	70.6	66.0	65.4	62.9	62.5	58.3	61.0	55.9	57.7	50.9

Table 47. Yields (q/ha) of varieties and varietal crosses grown as Experiment 923 at two locations in Tanzania in 1967.

Variety	KII(R11)C1	Ec573(R12)C1	KCA(S13)C1	KCB(67)	KCC(S)C1	KCE(67)	UCB-W	UCA	ZCA	IC-R	Variety
KII(R11)C1		29.6	29.9	29.9	38.4	24.1	32.2	37.4	32.5	36.8	28.9
Ec573(R12)C1	29.6		22.1	31.3	22.4	24.3	40.7	26.3	31.9	33.4	12.2
KCA(S13)C1	29.9	22.1		29.5	31.1	26.6	31.5	24.5	37.2	24.3	19.7
KCB(67)	29.9	31.3	29.5		28.4	24.6	27.9	29.5	29.9	32.6	29.0
KCC(S)C1	38.4	22.4	31.1	28.4		20.7	33.1	29.6	29.2	33.3	22.6
KCE(67)	24.1	24.3	26.6	24.6	20.7		27.5	32.3	30.5	32.4	25.3
UCB-W	32.2	40.7	31.5	27.9	33.1	27.5		32.0	32.3	25.7	33.3
UCA	37.4	26.3	24.5	29.5	29.6	32.3	32.0		33.1	28.2	28.3
ZCA	32.5	31.9	37.2	29.9	29.2	30.5	32.3	33.1		25.3	28.6
IC-R	36.8	33.4	24.3	32.6	33.3	32.4	25.7	28.2	25.3		22.2
Mean	32.3	29.1	28.5	29.3	29.6	27.0	31.4	30.3	31.3	30.2	25.0

Table 48. Yields (q/ha) of varieties and varietal crosses grown as Experiment 923 at two locations in Zambia in 1969.

Variety	KII(R11)C1	Ec573(R12)C1	KCA(S13)C1	KCB(67)	KCC(S)C1	KCE(67)	UCB-W	UCA	ZCA	IC-R	Variety
KII(R11)C1		53.3	41.3	44.3	59.1	46.0	39.9	55.5	58.1	44.1	27.9
Ec573(R12)C1	53.3		32.9	36.0	42.7	34.8	45.9	49.6	66.3	48.7	8.3
KCA(S13)C1	41.3	32.9		48.9	43.7	31.8	39.8	40.4	43.5	52.6	32.9
KCB(67)	44.3	36.0	48.9		44.3	47.5	50.8	52.3	55.4	39.2	40.7
KCC(S)C1	59.1	42.7	43.7	44.3		31.4	44.5	58.4	44.9	52.6	28.8
KCE(67)	46.0	34.8	31.8	47.5	31.4		44.8	49.9	48.7	49.5	40.3
UCB-W	39.9	45.8	39.8	50.8	44.5	44.8		37.5	45.1	38.3	41.4
UCA	55.5	49.6	40.4	52.3	58.4	49.9	37.5		39.6	46.5	40.1
ZCA	58.1	66.3	43.5	55.4	44.9	48.7	45.1	39.6		43.9	28.2
IC-R	44.1	48.7	52.6	39.2	52.6	49.5	38.3	46.5	43.9		35.3
Mean	49.1	45.6	41.7	46.5	46.8	42.7	43.0	47.7	49.5	46.2	32.4

TRAINING

Arrangements have been made with Makerere University for the PASA and CIMMYT staff at Kitale, and the EAAFRO and PASA staff at Serere to participate in graduate training; specifically to advise on thesis problems and in some cases to provide materials or supervise the research involved. The details of the operation will vary with the needs of a particular candidate.

Three individuals are now involved in this program. These are: Mr. Festus Ogada, Senior Maize Research Officer working on his Ph.D degree, and Mr. Gothecha and Mr. Makatiani who are M.S. degree candidates.

Mr. E. Omalo completed his B.Sc. in plant breeding at Iowa State University in June 1968 with the help of an AID fellowship. He was able to make his own arrangements to continue his studies for an M.Sc. degree in corn breeding with Dr. Russell at Iowa State. He completed the requirements in December 1969 and returned to Kenya. He has been given the responsibility for the protein quality and other research formerly done by Mr. Harrison.

Mr. B. Gichuhi was the assistant geneticist with the AID-ARS project from 1965 to 1967. Since that time he has been in charge of corn breeding at Embu. He has applied annually for an AID fellowship to complete his B.Sc. degree and M.Sc. at Iowa State. With the provision for training of counter parts, he is a logical candidate for this training. It would probably be desirable for him to get a B.Sc. degree.

Local Activities
Maize Breeding in Kenya
Festus Ogada

Mr. Festus Ogada, Senior Maize Research Officer, has general supervisory responsibilities for all maize research in Kenya, both breeding and agronomy. The Kenya national maize breeding program is handled as three separate units. The largest of these units is centered at the National Agricultural Research Station at Kitale. This program is intended to develop long season hybrids for the western highlands and any other areas with a single long rainfall period each year and in which the length of the rainfall period usually is not a limiting factor in maize production. Other areas of the country have two definite rainfall periods per year with a dry season intervening. Some of these areas have a rather dependable rainfall pattern, and high maize yields can be obtained.

However, hybrids are required that mature in a shorter period of time than do the long season Kitale hybrids. The maize breeding program for these areas is centered at the Agricultural Research Station at Embu. Other areas of Central and Eastern Province have two very short rainfall periods each year, and even within these short periods the rainfall is not dependable. Any maize with much possibility of producing an economic crop of grain must be able to reach the flowering stage in about eight or nine weeks from planting. The maize breeding program for these areas is centered at the Katumani Research Station near Machokos.

The Kenya national maize breeding program at Kitale is under the direction of Mr. Simeon Njuguna. This program presently consists of the improvement of two wide based composite varieties, Kitale Composite B (KCB) and Kitale Composite E (KCE). Recurrent selection based upon the evaluation of S_1 progenies in yield trials is being used in both of these composite varieties. It is expected that this selection will result in rapid improvement of both varieties and their cross. As soon as enough improvement has been obtained so that the varietal cross, KCB x KCE, equals or surpasses in yield the present commercial hybrids, then commercial production of this varietal hybrid will be initiated. Continued selection within the two parental varieties should result in a continually improving hybrid. Yield trials for the first cycle of selection in KCE were conducted in 1968 and for KCB in 1969. These trials have consisted of 363 S_1 lines each. Approximately 30 lines will be selected for recombining to form the new improved versions of the two varieties in each cycle. Use of irrigation facilities to aid in the recombinations and seed production for yield trials will permit the completion of a cycle of selection in two years. KCE and another newly-formed composite variety, Kitale Composite F(KCF), are being maintained under a system of 25% mass selection. These two populations are to be used as "back-up" populations in case the genetic variability in the S_1 recurrent selection programs with KCB and KCE become reduced to the point of limiting continued progress from selection.

The Kenya medium maturity maize program, now centered at Embu, is under the direction of Mr. Bernard Gichuhi. Previously this program was handled at Kitale but was shifted to Embu so that selection would not favor segregates suitable for the Kitale area but not suitable for the medium maturity requirements for Central Kenya. This program has been based upon the formation and selection within the two composite varieties Embu 11 and Embu 12. The varietal cross, Embu 11 x Embu 12, is the commercial hybrid H511. Both Embu 11 and Embu 12 have been

plagued by red, purple, and yellow seeded segregates, by a high incidence of ears with uncovered tips and by extreme variation in flowering dates. The previous program has consisted of mass selection to try to correct these faults and to improve yield, and has been only moderately successful. Present plans are to switch from mass selection to at least one cycle of selection among S_1 progenies to attempt to speed-up progress.

Two new composite varieties, Embu 1 and Embu 2, are being formed. These new composites are closely related to Embu 11 and Embu 12 but with the addition of more sources of exotic germ plasm. Plantings made in October 1969 were for the purpose of completing the fourth generation of composite formation with 25% mass selection. Embu 1 and Embu 2 are intended as replacements for Embu 11 and Embu 12 as soon as the performance of the new composites warrants the replacement. Intensive selection within Embu 1 and Embu 2 will begin as soon as the composite formation is considered completed.

All four Embu composites are in the process of conversion to opaque2 and floury 2 versions. The second backcross to the homozygous opaque 2 seed of all four composites was made in the Kitale nursery in 1969. The third backcross will be made at Embu in the October 1969 plantings.

The Kenya short seasonmaize breeding program at the Katumani Research Station was conducted by the maize agronomist, Mr. J.B.S. Makatiani, in 1969 after the death of Mr. Henry Mauuye early in the year. The position of maize breeder remained vacant at the end of 1969. The breeding program consists of some form of cyclic selection in two streams of germ plasm. The particular selection method has varied considerably from cycle to cycle. New sources of germ plasm have been fed into each stream in each cycle of selection. The present cycle in the two streams are designated Katumani VII and Katumani VIII. Advanced generations of the cross Katumani VI x Katumani V has been designated as Katumani Synthetic B and has been released for commercial production as a synthetic variety. A program to obtain opaque 2 versions of Katumani Synthetics VII and VIII is underway.

Mr. Michael Harrison, an employee of CIMMYT (the International Maize and Wheat Improvement Center - a joint agency of the Rockefeller and Ford Foundations), has been conducting a program to introduce certain simply inherited characteristics into some of the Kenya composite

varieties. The gene brachytic 2, which reduces the length of internodes below the ear, is being introduced into KCB and KCE. Genes opaque 2 and floury 2, which affect the amino acid distribution in the grain, are being introduced into all Kenya composite varieties to improve protein quality. The Ht gene for resistance to the leaf blight caused by *Helminthosporium turcicum* was introduced into several varieties. Cytoplasmic male sterility also was being introduced as a possible aid in commercial seed production. Mr. Harrison's assignment to this program was terminated in late 1969, and he was not replaced. Part of the program on the brachytic 2, opaque 2 and floury 2 genes will be continued as part of the Kenya national maize breeding program insofar as the availability of funds and personnel permit.

Maize Breeding Method Studies
Lowell H. Penny and Charles Ndegwa

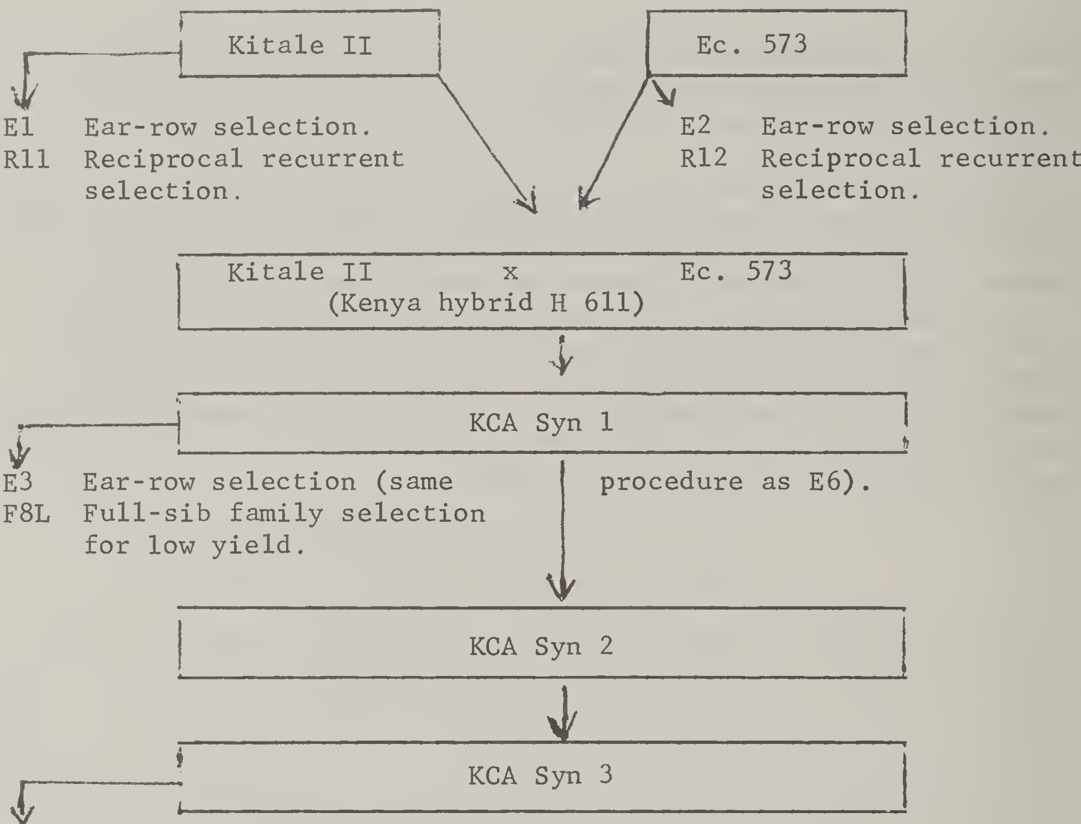
The USAID/ARS/EAAFRO maize improvement research program is headquartered at the National Agricultural Research Station, Kitale, Kenya. It was conducted in 1969 by Dr. L. H. Penny, Research Geneticist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture; assisted by Mr. Charles Ndegwa, Assistant Agricultural Officer, Kenya Ministry of Agriculture. Field and laboratory facilities and supporting field staff were provided by the Kenya Government reimbursed by USAID through EAAFRO. Close collaboration continued with the personnel of the Kenya Maize Research Section at Kitale, Embu and Katumani and with other personnel of the Kenya Ministry of Agriculture at the Njoro and Kakamega Research Stations. Collaboration in the form of field trials of the Eastern African Maize Variety Trials and Eastern African Variety Diallel Trials also continued at several locations in Ethiopia, Uganda, Tanzania, Kenya, Zambia and Malawi.

Maize Breeding Method Research

The primary objectives of the maize breeding method research program are to evaluate the relative efficiencies of various maize breeding methods and to adapt these methods to conditions in developing countries so that local breeding programs can make maximum progress for the minimum expenditure of funds. Comparisons of 17 different selection programs were initiated in 1964 in the three heterogeneous populations, Kitale Synthetic II (KII), Ecuador 573 (Ec.573) and Kitale Composite A(KCA). This latter population was developed as the advanced generation of the cross KII x Ec.573. The 17 selection

programs represent variations of the population improvement methods mass selection, ear-row selection, full-sib family selection, recurrent selection and reciprocal recurrent selection. An outline of the program is given in Figure 1.

The selection programs initiated in 1964 were continued in 1969. Yield trials for selection purposes were planted at four locations. Yield trials for preliminary evaluations of progress from the early cycles of selection were planted at seven locations. All yield trials both for selection and evaluation purposes at one location, Njoro Plant Breeding Station, were discarded because of drought damage. Seed was produced in the breeding nursery at Kitale for further selection and evaluations in 1970. The locations and approximate altitudes in meters at which comparative replicated yield trials were planted in 1969 are listed below.



<u>Ear-row selection</u>

E4 23,438 plants/ha., no selection among males, 49 entries.
E5 46,876 plants/ha., no selection among males, 49 entries.
E6 46,876 plants/ha., 50% selection among males, 49 entries.
E7 46,876 plants/ha., 50% selection among males, 100 entries.

<u>Mass selection</u>

M9 2% selection intensity.
M10 10% selection intensity.

<u>Recurrent selection - recombination of selected S_1 lines</u>

S13 S_1 line evaluation.
H14 Testcross evaluation, parent population tester.
HL15 Testcross evaluation, low yield population (F8L) tester.
HI16 Testcross evaluation, inbred line tester.

<u>Full-sib family selection</u>

F18 Recombination of selection full-sib families.

Figure 1. Outline of Maize Breeding Method Study

Location code	Approximate Altitude(m)	Location
01	1,890	Kitale (Top Farm, N.A.R.S.)
02	1,860	Endebess (W.E.Strong farm)
03	1,524	Kakamega (Agric. Res. Stn.)
04	2,195	Njoro (Plant Breeding Stn.)
05	1,890	Kitale (Grasslands, N.A.R.S.)
07	2,134	Mt.Elgon (Chorlim Farm)
19	1,464	Embu (Agric. Res. Stn.)
45	1,220	Busia (Expt. Sub-station)

Current results from the selection trials are not presented here. The low yields and high coefficients of variation for the trials at the Kakamega location are thought to be due in part to very severe lodging that occurred at that location. The estimates of variance components, heritabilities (H), selection differentials (D), and expected gain from selection for each cycle in each of the programs are on file at Kitale. Heritabilities were calculated as

$$S_g^2 \,/\, S_{ph}^2, \text{ where } S_{ph}^2 = \frac{S_e^2}{r\iota} + \frac{S_{ge}^2}{\iota} + S_g^2.$$

In the above expressions S_{ph}^2, S_g^2, S_{ge}^2, and S_e^2 are estimates of the phenotypic variance, genotypic variance due to differences among entries, genotype x environmental variance due to the interaction of entries and locations, and error variance respectively; and ι and r are the number of locations and the replications within locations, respectively. The expected gain was calculated as ½ HD for the ear-row experiments and HD for all others.

The selected lines from each of the breeding method experiments are given below.

E1 35-04-02-02-06-05, 35-04-02-09-09-06, 35-04-12-06-06-08, 35-04-12-06-06-10, 35-04-12-06-06-12.

E2 12-02-02-02-02-03, 12-02-02-05-04-02, 12-02-02-05-04-04, 12-02-02-05-04-12, 36-10-09-08-04-06.

E3 18-02-06-10-05-08 18-02-06-10-05-10, 18-02-06-10-06-03, 18-02-06-10-06-09, 18-02-06-10-08-12.

E4	12-04-02-03-10, 33-02-11-06-06,	12-04-10-09-08, 33-02-11-06-11.	33-02-11-02-09,
E5	32-05-06-04-05, 32-05-06-12-05,	32-05-06-06-09, 32-05-06-12-08.	32-05-06-12-04,
E6	27-08-02-02-03, 40-09-05-06-11	27-08-02-02-10, 43-03-05-04-11.	40-09-05-06-02,
E7	59-05-02-02-02, 59-11-09-05-11, 66-02-04-08-05, 66 08-02-04-11.	59-05-02-02-04, 59-11-09-11-08, 66-02-04-08-09,	59-08-10-08-09, 59-11-10-06-09, 66-08-02-04-10,

R11 (2 x 83)-2, (3 x 27)-2, (3 x 79)-2, (3 x 4)-2, (53 x 21)-4, (53 x 27)-1, (83 x 27) 6, (83 x 18)-5, (83 x 4)-1, (87 x 18)-3.

R12 (76 x 68)-6, (68 x 30)-4, (54 x 30)-2, (54 x 46)-1, (54 x 50)-3, (54 x 14)-2, (96 x 70)-2, (96 x 14)-5, (38 x 30)-3, (70 x 14)-6.

HI16 (35 x 44)-3, (35 x 55)-3, (44 x 99)-4, (44 x 84)-2, (99 x 94)-3, (21 x 55)-5, (21 x 94)-6, (55 x 64)-5, (55 x 94)-4, (55 x 31)-6.

F18 (77 x 87)-2, (77 x 60)-3, (77 x 42)-3, (34 x 07)-2, (34 x 67)-2, (10 x 68)-2, (87 x 27)-1, (87 x 68)-1, (42 x 67)-2, (42 x 68)-1.

Evaluation of Progress from Selection

The original and selected strains from the most recent cycle of selection from the breeding method study were compared as Experiment 924. Trials were planted at seven locations, and data were obtained from six. Field design was a 5 x 5 triple lattice at each location. Plant population was approximately 46,876 per hectare (18,970 plants per acre) with a spacing of 80 centimeters between rows and $26\frac{2}{3}$ centimeters between plants within rows. Yields are presented for all locations in Table 49. A summary of all agronomic data is presented in Table 50. There were indications of some progress from selection in most of the selection programs, but most of the yield differences were not sufficiently large to be statistically significant. The Ec.573(E2)C4 population yielded significantly more

than the original Ec.573. However, the apparent yield increase was probably inflated by the depressed yield of the original Ec.573 due to poor stands. Changes in plant characters (reduced purple pigmentation and pubescence of the leaf sheaths) and ear characters (increased ear diameter, kernel row number, and kernel denting) in the Ec.573(E2) strain suggest that the increased yield of this strain may be due not only to the selection practised but also to introgression of germ plasm from other sources in early stages of the selection program.

Data from advanced populations of the other selection schemes were inconclusive, ranging from a significant reduction in yield to small non-significant increases. The significantly lower yield of KCA(HL15)Cl population may have been caused by poor seed quality as indicated by the poor stands. No clear explanation for the reduced yield of the KCA(S13)Cl population is apparent, although seed quality may have been involved here too.

Reductions in ear heights and the number of days from planting to tassel were indicated in all of the populations resulting from recurrent or reciprocal recurrent selection - Kitale II(R11), Ec.573(R12), and KCA(S13), (H14), (HL15), and (HI16). No such changes were apparent in the populations obtained through mass selection or ear-row selection.

Table 49. Yields (q/ha) of original and selected populations and crosses derived from the maize breeding method study, grown as Experiment 924 at six locations in Kenya in 1969.

Entry	Location Code						
	01	02	03	05	07	45	Mean
Kitale II CO	59.7	77.5	39.2	52.3	72.2	16.3	52.9
Kitale II CO	52.5	81.9	47.4	59.0	64.5	25.0	55.0
Kitale II(E1) C4	64.5	68.4	59.7	61.5	74.9	23.0	58.7
Kitale II(R11) C2	68.3	79.9	44.6	48.1	80.4	25.7	57.8
Ec573 CO	52.4	51.1	31.9	40.8	65.9	6.8	41.5
Ec573 CO	46.2	48.8	21.9	34.7	55.8	6.2	35.6
Ec573(E2) C4	62.8	72.1	33.9	63.6	92.4	15.5	56.7
Ec573(R12) C2	52.8	65.8	27.7	53.7	71.6	9.5	46.9
KCA CO	78.7	78.5	35.6	70.5	96.8	19.2	63.2
KCA CO	75.4	81.9	39.6	62.1	88.5	19.2	61.1
KCA(E3) C4	74.5	76.5	32.3	67.7	105.1	18.9	62.5
KCA(E4) C3	91.5	77.2	54.0	60.4	89.1	26.4	66.4
KCA(E5) C3	63.9	79.4	54.5	70.9	108.3	23.3	66.7
KCA(E6) C3	68.2	91.1	59.4	67.8	84.5	22.6	65.6
KCA(E7) C3	73.4	82.3	54.3	73.7	99.3	27.0	68.3
KCA(M9) C4	81.1	79.1	45.0	69.2	88.0	18.6	63.5
KCA(M10) C4	68.0	71.7	33.6	68.1	99.3	21.2	60.3
KCA(S13) C1	61.9	59.2	42.3	57.3	64.1	20.0	50.8
KCA(H14) C1	78.3	86.6	58.7	66.0	98.7	31.4	69.9
KCA(HL15) C1	66.9	68.4	51.4	42.8	55.0	20.7	50.9
KCA(HI16) C1	66.2	75.3	47.6	59.7	83.9	22.8	59.3
KII CO x EC573 CO	87.4	100.0	66.3	62.7	123.2	29.8	78.2
KII(R11)C1 x Ec573(R12)C1	89.6	111.7	67.7	70.1	109.5	31.9	80.1
KII(R11)C2 x Ec573(R12)C2	97.8	108.4	79.1	93.0	101.7	29.4	84.9
H611B (Commercial)	89.4	108.2	64.3	71.1	116.6	34.0	80.6
Mean	70.9	79.2	47.7	61.9	87.6	21.8	61.5
L.S.D. (.05)	22.8	15.7	22.3	14.5	19.1	8.6	9.4
C.V. (%)	19.7	12.2	28.7	14.3	13.4	24.3	

Table 50. Agronomic data obtained on unselected and selected populations and crosses derived from the maize breeding method study, grown as Experiment 924 at six locations in Kenya in 1969.

Entry	Yield q/ha	Stand %	Lodging %	Bare tips per 100 plants	Usable ears per 100 plants	2/ Days to tassel	1/ ear height cm.
Kitale II CO	52.9	93.1	50.7	7.1	67.1	96.0	221.0
Kitale II CO	55.0	92.1	43.3	6.2	72.6	96.5	217.1
Kitale II(E1) C4	58.7	95.4	40.5	9.8	75.1	95.2	218.0
Kitale II(R11) C2	57.8	94.6	37.7	6.6	83.1	92.8	203.5
Ec573 CO	41.5	86.0	43.7	26.3	69.4	103.7	246.7
Ec573 CO	35.6	81.0	41.8	37.1	67.8	104.5	243.7
Ec573(E2) C4	56.7	94.6	44.1	20.9	78.4	99.8	244.7
Ec573(R12) C2	46.9	91.6	45.2	3.2	74.0	98.5	234.2
KCA CO	63.2	95.4	31.8	7.2	78.6	95.2	235.9
KCA CO	61.1	94.6	32.3	13.1	80.1	95.5	232.8
KCA(E3) C4	62.5	94.9	38.1	11.1	81.4	94.5	236.0
KCA(E4) C3	66.4	95.1	32.1	13.8	82.7	95.2	235.3
KCA(E5) C3	66.7	96.9	39.6	13.1	80.6	94.3	234.1
KCA(E6) C3	65.6	93.3	32.7	13.4	80.7	95.0	232.6
KCA(E7) C3	68.3	95.6	41.5	11.0	82.3	93.2	233.2
KCA(M9) C4	63.5	94.1	39.7	13.2	80.1	99.3	242.3
KCA(M10) C4	60.3	94.6	43.0	12.4	76.2	96.0	245.6
KCA(S13) C1	50.8	91.8	38.4	16.8	73.6	92.4	209.2
KCA(H14) C1	69.9	93.3	30.9	18.1	88.1	92.3	217.1
KCA(HL15) C1	50.9	84.5	35.4	9.8	74.9	91.7	199.6
KCA(HI16) C1	59.3	94.1	34.1	18.9	78.2	93.5	224.2
KIICO x Ec573 CO	78.2	93.6	30.9	17.0	84.2	94.2	241.3
KII(R11)C1 x Ec573(R12) C1	80.1	95.4	33.8	15.3	88.3	93.5	230.2
KII(R11)C2 x Ec573(R12) C2	84.9	94.1	27.7	7.3	90.4	91.2	226.9
H611B (Commercial)	80.6	94.1	32.6	15.1	87.6	95.7	247.1
Mean	61.5	93.0	37.7	13.7	79.0	95.6	230.0
L.S.D. (.05)	9.4	4.8	10.2	7.3	9.1	--	--

1/ Five locations 2/ Two locations

Improvement of Hybrids H611 and H613

The breeding method study is intended primarily to produce information on relative efficiencies of several breeding methods. It also is expected to produce a by-product in the form of improved plant materials for use in hybrids in Kenya and other Eastern African countries. Both the Kenya hybrids H611 and H613 have Ec.573 as the male parent. The current commercial versions, designated H611B and H613B, have the original strain of Ec.573 as male and Kitale III and F x G, respectively, as seed parents. Kitale III is a strain developed from Kitale II by Mr. M N. Harrison by one cycle of recurrent selection with the parent variety, Kitale II, as tester. F x G is a single cross between two homozygous inbred lines developed by Mr. Harrison. If either the reciprocal recurrent selection or ear-row selection programs for improvement of Kitale II and Ec.573 are successful, the new improved strains could be substituted for the originals in the production of H611 and H613.

Data were obtained in 1969 from two sets of experiments that can be used to indicate expected improvement in H611 and H613 if the improved parental strains were used. Data from relevant entries in Experiment 923 and 924, both grown at the same six locations with three replications per location, are shown in Table 51. The (F x G) x Ec.573 CO and commercial H613B are supposed to be identical genetically, and any differences between them probably were due to chance variation or possible seed quality differences. Yields of the H613 version with Ec.573(R12)C2 as male parent exceeded those of the versions utilizing the original strain of Ec.573 by 17% and 11%. There was also some indication of slight improvement in other characters. In the H611 comparisons the C2 x C2 version outyielded the CO x CO and C1 x C1 versions by 18% and 7%, respectively, in Experiment 923 and by 9% and 6%, respectively, in Experiment 924. The commercial H611B was very similar in performance to the C1 x C1 version. Some improvement in other characters was indicated in the advanced version of H611 as well.

The Kenya Seed Company began making their first changes in the H611 and H613 with the seed produced in 1969. A small part of the production of both H611 and H613 utilized Ec.573 (R12)C2 as male parent. The change to this new strain of Ec.573 will be made as soon as seed supplies permit. It is anticipated that the improved Ec.573 will be used for all of the H611 produced in 1970 and for all of the H613 produced in 1971. As soon as the change-over is completed, these two hybrids will be redesignated H611C and H613C. No immediate change is anticipated in the seed parents of either hybrid until more improvement is made in the Kitale II.

Yield data obtained in 1967 and 1968 on the new cycles of Ec.573 derived from the breeding method study indicated more rapid improvement of the ear-row derived strain (E2) than the reciprocal recurrent selection derived strain (R12). Acting upon this information, the Kenya Seed Company planted an isolation increase block of the Ec.573(E2)C4 in 1969 to obtain seed for future use in the production of hybrids H611 and H613. Close examination of the plants in this block during the season and the ears at harvest produced evidence that this strain of Ec.573 had undergone certain changes that might be expected from introgression of germ plasm from another source. No proof is at hand that the changes were due to contamination rather than selection within the genetic variability present in the original Ec.573. However, persons familiar with the original Ec.573 had never observed the extent of kernel denting, the large diameter ears, or the number of green stalks without hairs on the leaf sheath in Ec.573 as was evident in this plot. The changes that have taken place in this E2 strain of Ec.573 have resulted in higher yields of the population per se. However, no data are presently available to indicate the extent or direction of change that may have occurred in its yield in crosses with Kitale II or related strains. In the absence of such information, the increase block of Ec.573(E2)C4 was discarded.

Table 51. Agronomic data obtained on original, improved, and commercial versions of H611 and H613 in Kenya in 1969.

Hybrid	Yield q/ha	Stand %	Lodging %	Bare tips per 100 plants	Usable ears per 100 plants	Days to tassel	Ear height cm.
	Experiment 923 - 6 locations, 3 replications per location						
(F x G) x Ec573 CO	73.1	97.5	62.0	22.6	83.1	94.6	232.0
(F x G) x Ec573(R12)C1	55.5	82.1	52.0	16.2	68.7	92.6	222.2
(F x G) x Ec573(R12)C2	81.1	98.7	49.8	18.1	91.0	92.9	221.2
H613B (Commercial)	69.5	93.7	58.0	32.4	83.4	93.8	226.3
KII CO x Ec573 CO	68.0	94.7	55.8	16.0	75.1	94.4	239.5
KII(R11)C1 x Ec573(R12)C1	74.6	97.0	53.4	14.8	82.3	94.7	231.1
KII(R11)C2 x Ec573(R12)C2	80.1	96.5	41.1	6.8	86.2	93.2	227.0
H611B (Commercial)	74.0	93.7	49.6	22.8	76.9	95.3	244.0
LSD (.05)	12.1	4.6	13.0	7.9	11.2	2.4	11.6
	Experiment 924 - 6 locations, 3 replications per location						
KII CO x EC573 CO	78.2	93.6	30.9	17.0	84.2	94.2	241.3
KII(R11)C1 x Ec573(R12)C1	80.1	95.4	33.8	15.3	88.3	93.5	230.2
KII(R11)C2 x Ec573(R12)C2	84.9	94.1	27.7	7.3	90.4	91.2	226.9
H611B (Commercial)	80.6	94.1	32.6	15.1	87.6	95.7	247.1
LSD (.05)	9.4	4.8	10.2	7.3	9.1	2.2	10.7

Seed Production and Distribution
Lowell H. Penny

No economic returns can be realised from any crop breeding program until the results of that program are grown on farmers' fields. This requires some form of seed production and distribution service. The first hybrid maize was produced in Kenya in 1962. Production is handled on a contract basis with selected farmers growing the crop and the Kenya Seed Company of Kitale agreeing to buy and process all seed produced. Seed production is done under certification standards equal to those of the International Crop Improvement Association. Necessary field inspections are carried out by Kenya Government inspectors. The processed seed is distributed through the sales organization of the two companies, Kenya Farmers' Association and Dalgety (E.A.) Ltd.

Originally hybrid maize production was on a very limited scale but recently has increased rapidly. Six hybrids are now being produced. In 1969 2,264 acres were produced by 58 producers. Twenty of the producers were African farmers, and the other 38 were Non-African farmers. This was an increase of 12 growers and approximately 1,000 acres from 1968. Most of the seed was used for planting in Kenya but some is exported for planting in other Eastern African countries. Estimates of the acreages of each hybrid grown on farms in Kenya and other countries in 1969 from Kenya-grown hybrid seed are presented in Table 52. These estimates were calculated from seed sales (statistics provided by Mr. E.J.R. Hazelden of the Kenya Seed Company) and with the assumption that 20 pounds of seed were used per acre. H613B was by far the most popular hybrid, accounting for nearly half the total acreage planted to hybrid seed.

Trends in the use of hybrid seed can be seen from the data shown in Table 53. Acceptance of hybrid maize was very rapid on the large scale farms, reaching a maximum acreage in 1967. Nearly all of the maize acreage on the large scale farms has been planted to hybrid seed each year since 1967. Seed sales to small scale farmers increased more slowly but are continuing to increase. The hybrid acreage on small scale farms has exceeded that on large scale farms in both 1968 and 1969. Although this trend is encouraging, a much larger expansion of the use of hybrid seed by small scale farmers needs to be made. Even in 1969 only approximately 6% of the estimated 2,500,000 acres of small scale farm maize was planted to hybrids.

Hybrid seed production on a small scale was tried successfully in 1969 by the Tanganyika Wattle Company Limited of Njombe, Tanzania. This first production was of the Kenya hybrid H611B. Seed increases

were made of Kitale Synthetic III, Kitale Synthetic II(R11)C2, Ec.573 (original) and Ec.573(R12)C2. Further production of H611B (using Kitale Synthetic III and Ec.573 original) or an improved version of H611 (using the improved Kitale Synthetic II and Ec.573 strains) was planned for the 1969-70 growing season.

Table 52. Acres of hybrid maize grown in 1969 from seed produced in Kenya.

Hybrid	Kenya Large scale farms	Kenya Small scale farms	Kenya Total	Other countries
H511	875	4,398	5,273	278
H611B	16,185	12,755	28,940	1,022
H612	4,135	14,809	18,944	100
H613B	61,780	62,204	123,984	1,966
H622	8,590	27,115	35,705	14,157
H632	6,040	37,583	43,623	19,934
Total	97,605	158,864	256,469	37,457

Table 53. Acres of hybrid maize grown in Kenya, 1963 to 1969 (estimated from seed sales).

Year	Large scale farms	Small scale farms	Total
1963	385	10	395
1964	28,169	1,730	29,899
1965	54,856	20,015	74,871
1966	63,011	37,806	100,817
1967	137,141	115,396	252,537
1968	100,323	129,233	229,556
1969	97,605	158,864	256,469

SORGHUM and MILLETS IN EAST AFRICA

H. Doggett
E.A.A.F.R.O. Sorghum Research Division

Sorghum and millets are currently of greatest interest to Tanzania and Uganda, although these cereals will one day have an important contribution to make in the extensive semi-arid areas of Kenya. The establishment of seed production schemes in Tanzania and Uganda is therefore an important development. Hybrid sorghum seed was produced successfully for the first time on a pilot scale by the Uganda Seed Scheme during the latter part of 1969, and the demand for the sorghum variety "Serena" greatly exceeded the quantity of seed multiplied. Seed production will increase steadily from now on, and it should not be long before improved finger millets developed at Serere are being multiplied. Tanzania is ready to follow suit, and in that country seed of white grained sorghums and of bulrush millet will be important. The development of this essential link between the cereals research work and the farmer will result in practical use being made of the better cereal varieties and hybrids being developed at Serere.

The rainfall at Serere during 1969 was average in amount, but very unevenly distributed. March and April were unusually dry for the first rainy season, while during the second rains only 110 mm of rain fell between August 3rd and October 5th. Serere cereals yields were only slightly affected, but in the district finger miller and sorghum yields were very poor, and there has been a widespread shortage of food which will continue until June 1970. This underlines the need for timely land preparation and planting, accompanied by good management. Much more ox-drawn or tractor drawn equipment is needed to ensure timely land preparation and seeding, but the average small farmer just has not got the capital to buy such essential items.

Breeding for pest resistance in sorghum has made good progress during the past year. Both shoot-fly seedling resistance and recovery resistance (tolerance) are being crossed in to local material, and into populations for improvement by recurrent selection. The seedling resistance came from work done mainly by Rockefeller Foundation staff in India, and should supplement very usefully the recovery resistance developed here. Recurrent selection for resistance to <u>Chilo</u> stem-borer looks very promising, the main bottle-neck at the moment being the lack of a wholly artificial diet for rearing the larvae. Natural diets cannot be fully sterilised and larval mortality from disease attack prevents the production of the pest in sufficient numbers to infest the size of plant populations required.

The agronomy studies have revealed some of the problems in obtaining high production levels both on Serere and in the district, and further work is needed to find out what factors are limiting cereal yields. The herbicide studies should also have valuable application. In countries where seeders are rare and broadcasting is the usual sowing system, herbicides used in conjunction with reasonable land preparation and a fertiliser mixture might well make the growing of broadcast cereals productive and profitable. Certainly the spacing trials indicate that yield is not affected by a wide range of plant populations, once a minimum level has been passed.

The breeding of the millets has made good progress: stronger straw in finger millet is essential before nitrogenous fertilisers can be used effectively on the crop: and the application of recurrent and selection methods to this crop is likely to be very profitable. The bulrush millet work continues to show what a valuable potential this crop has, in terms of yield combined with good quality and quantity of protein.

Sorghum Breeding

H. Doggett, S. Z. Mukuru, R. E. Okello
H. C. Ojulong, P. A. Ajau and B. Okwi

Hybrid sorghum. The best hybrids so far developed here have all been too tall. This season, an extensive series of crosses of Serere-bred selections to CK 60A showed up pollinator lines giving hybrids with short straw, notably in families 5DX 36, 5DX 61, and 5DX 76. A good short non-restorer selection came from family 5DX 87. These hybrids have yet to be yield tested in the Regional trials, but observations are promising. Some of the 5DX 36 lines combine satisfactory grain quality with tan plant color, while certain of the 5DX 61 lines compare favourably with Serena in yield for the coarse grain areas. Both of these families could give good varieties, and it is an advantage for seed production if the pollinator parent of the hybrid can be issued as a variety.

The production of shortened forms of non-restorers of known good combining ability was continued, and a useful series of new dwarf non-restorers was received from India. Probably the most useful accessions in this respect will prove to be the lines from the Puerto Rico conversion programme, some of which have now been grown at Serere.

The Indian hybrid CSH-1 was tested at a number of sites, its susceptibility to bird damage restricting the areas where it could be grown. Results so far received are summarised in Table 54.

Table 54. Grain yields in kg/ha of the Indian hybrid CSH-1

	Kenya	Tanzania	Uganda
Number of sites	4	5	9
CSH-1	2,255	2,830	1,640
Serena variety	3,040	2,445	2,115

CSH-1 will be tested further in Tanzania.

The Serere hybrid 471 [= CK 60 x (5DX 36/1)] has been put out for observation in Tanzania, as it has a white grain of fair quality. The version under test is tall, but the short form will be produced next year.

Varietal improvement. Routine screening of Serere lines continued, and some yields are summarised in Table 55.

Table 55. Grain yields in kg/ha of sorghum families developed from crosses made in 1965 and 1966.

Family	Yield	Family	Yield	Family	Yield
5DX 36/2	5,285	5DX 174	4,350	5DX 126/12	4,020
6DX 14	4,690	6 DX 2	4,220	5 DX 157	3,945
5 DX 135/13	4,575	6 DX 9	4,050	Dobbs	3,615
5DX 142/4	4,540	6DX 10	4,050	Serena	3,595

The main effort in 1969 went into the quality grains, as coarse grained types with reasonable yield are now available. The variety 5DX 36/1 was put out for observation in Tanzania, where acre plots are being grown at some 70 sites. It was also used as a parent in a series of crosses with the object of producing a plant with better yield, better grain quality, and better leaf disease resistance than 5DX 36/1.

Population Improvement. The 8 initial populations (PRS 1-4 and RS 1-4) were subjected to different types of selection - (a) female choice, i.e. normal gridded mass selection, taking only male-sterile plants, (b) alternating female choice and selfed plant selection, in which seed from the best fertile heads is taken in every alternate generation, (c) S_1 testing. This had to be restricted to only 4 of the populations, as 8 triple lattice trials of 13 x 13 entries each was all that we could manage. The importance of complementary gene action is becoming evident, as might be expected in a largely self-pollinated crop. This results in some wild type characters appearing, such as shedding sessile spikelets, but the most evident effect is on height.

It will probably be necessary to cross S_1 lines to a tester in order to obtain uniform height. Strong selection pressure for yield cannot be applied at high plant populations unless the plants are of genetically similar height, since the greater competitiveness of the taller plants results in their being selected preferentially.

Compositing was begun of entries from the World Collection which had been crossed with ms_3 stocks, and backcrossed to the appropriate entry. The "Irish" system was used, in which the World Collection ms_3 entries were interplanted with rows of a pollinator bulk composed of some seed from all entries, well mixed together. Two composites have been started in this way, 561 World Collection varieties going into a restorer composite, and 111 into a non-restorer composite.

We received a little seed from each of 292 entries out of the Puerto Rico conversion programme. Crosses to the Serere PRS and RS populations as well as to the new World Collection lines were successfully made from 256 of these new accessions, the total number of crosses being 1021. The F_1 generation is almost ready for harvest at the time of writing, and seed of each cross will be returned to the United States. It is to be hoped that interchanges of this type may prove of mutual benefit; certainly the availability of so many 4-dwarf stocks on a wide genetic base will make an important contribution towards solving the height problems in the hybrids and populations being developed on Serere.

Compositing of the "High Altitude," "Ethiopian," and "Hybrid RS" populations was completed, and the F_1 of the bulk crosses of ms_3 to a range of Sorghum Shoot Fly resistant material was also grown.

Tetraploid grain sorghum. The tetraploid ms_3 stock was crossed to the Serere tetraploid mixtures, and the F_1 and F_2 generations grown. Steriles from the F_2 were pollinated from within the same row, and an F_3 will be grown, to increase the number of male-steriles present before making the backcrosses. A population was begun by mixing together all available tetraploids with some of the ms_3 stock, and keeping only seed from the sterile heads.

Millet Breeding Program

Leroy V. Peters

The evaluation and breeding program of the two millets, Finger Millet, Eleusine coracana and Bulrush Millet, Pennisetum typhoides, although centered at the Serere Research Station, and primarily intended for the three East African countries, has now extended its testing program into two countries in West Africa and two in South Africa. Both of these millets are ecologically adapted to many areas of Africa and in many areas they are the staple food. Improvement in both quantity and quality of grain can greatly improve the economy and health of the people.

Finger Millet Breeding

L. V. Peters, D. Ocenodongo
S. Odele and E. Atadan[1/]

Regional Trials

Most of the finger millet is grown during the first rain season of the year in Uganda. From the results of the 1968 trials at Serere Research Station, the number of entries selected for testing in the regional trials for the first rains of 1969 were increased to 25 selections as compared to 12 for the previous years. Yield data shown in Table 55 from 18 District Variety Trial Centers in Northern Uganda reveal that drought conditions and/or a low level of soil fertility were evident at some areas, however, good growing conditions prevailed at others. Yields on an average were not as good as in 1968, but the high yielding entries in previous years trials were among the top entries in 1969. Significant differences in yield were found at twelve trial sites with varieties Serere 104, Serere 1, Serere 116, Eding, Serere 358, Gulu E. Engeny, and Engom being the top entries.

These results strongly indicate that some varieties are much better adapted than others and that very good yields can be attained when moisture and soil fertility is not limiting. At centers which were able to apply nitrogen as either ammonium sulfate or ammonium nitrate at from 47 to 52 kilograms of nitrogen per hectare (42-46 pounds/acre) and single super phosphate at 36 to 40 kilograms of water soluble P_2O_5 per hectare (32-36 pounds/acre), yields of over 50 quintals per

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hectare (4460 pounds/acre) of clean dry grain were obtained. With close row plantings with at least one half million plants per hectare (two hundred thousand plants per acre) yields many times that of the average farmer in Uganda can be attained.

Strain Evaluation

Significant information on strain evaluation obtained at Serere during the first rains of 1968 was the basis for two trials, one hundred entries each, which was conducted during the first rains of 1969. A number of selections from the World Collection with phenotypic characteristics of the high yielding entries in the 1968 tests, were selected for these two trials. The high yielding, lodge and blast resistant strains will be further evaluated in the regional trials and will also be incorporated into our improvement program.

Improvement Program

With the use of hot water emasculation techniques, it is possible to make crosses between the different strains of finger millet. Breeding resistance to blast, *Piricularia oryzae*, was continued, with 440 third and fourth backcrosses being made to incorporate resistance and high yield. Lodge resistance is also being crossed into this germ plasm.

The development of the broad gene pool which was initiated in 1968, with the 597 entries from the World collection, was expanded to include the additional 155 New Introductions from Ethiopia.

There were 178 crosses made between selected F_1 plants of crosses made in 1968 and 357 new crosses which included both the World Collection and the New Introductions. This intercrossing program will continue for some time before allowing plants to stabilize themselves. However, F_2 seed is being harvested and selection from within this segregating material can be started.

Selection for strains of finger millet which are high in protein are looking more favorable than was previously assumed. Although the protein content on an average is lower than in most of the cereals, preliminary analysis of some strains show it to be equal and in some instances higher in the three essential amino acids, lysine, methionine and tryptophane.

Bulrush Millet Breeding

Regional trials

The strains of bulrush millet developed at Serere Research Station are types which are medium to early in maturity as compared to the strains from West Africa. Eight bulk populations have been developed, which are all good restorers when crossed onto Tift 23A. Yield data from fifteen centers in Uganda and two in Tanzania are shown in Table 56. Significant differences in grain yield were found at eleven centers. All eight hybrids yielded more than their pollinators at Pakelle, Aduku, Serere and Kasese. In the comparison of the hybrids with their pollinators, the hybrids yielded more than their pollinator on 91 occasions, the pollinators outyielded their hybrid 40 times, and five had equal performance in a total of 136 comparisons. The average yield of each hybrid was greater than their pollinator, however, only four of the hybrids gave yields significantly greater than their pollinator.

World Collection

As indicated in the 1968 Annual Report, the primary breeding program towards the use of the germ plasm of the World Collection is to separate the accessions into either restorer or non-restorer groups, as determined by the performance of Tift 23A hybrid. But those which produce good fertile hybrids can also be used directly in the hybrid testing program. The outline for this program is illustrated in Figure 2 and two recombination cycles of the continuation scheme of both the restorer and non-restorer population have been completed. Selections from 1026 new accessions evaluated in 1969 have been selected and added to these two populations. At least two more cycles of recombinations will be allowed before selection pressure will be applied. This, however, will be started in 1971.

Selection of Adapted Restorers

There were 142 Serere selections crossed to Tift 23A in 1968 and classified during the first rain season of 1969. Results indicate that 139 were good restorers, and 3 were non-restorers. From the performance of the World Collection and East African material thus far, it appears that about 5 per cent of the pure strains are non-restorers on Tift 23A.

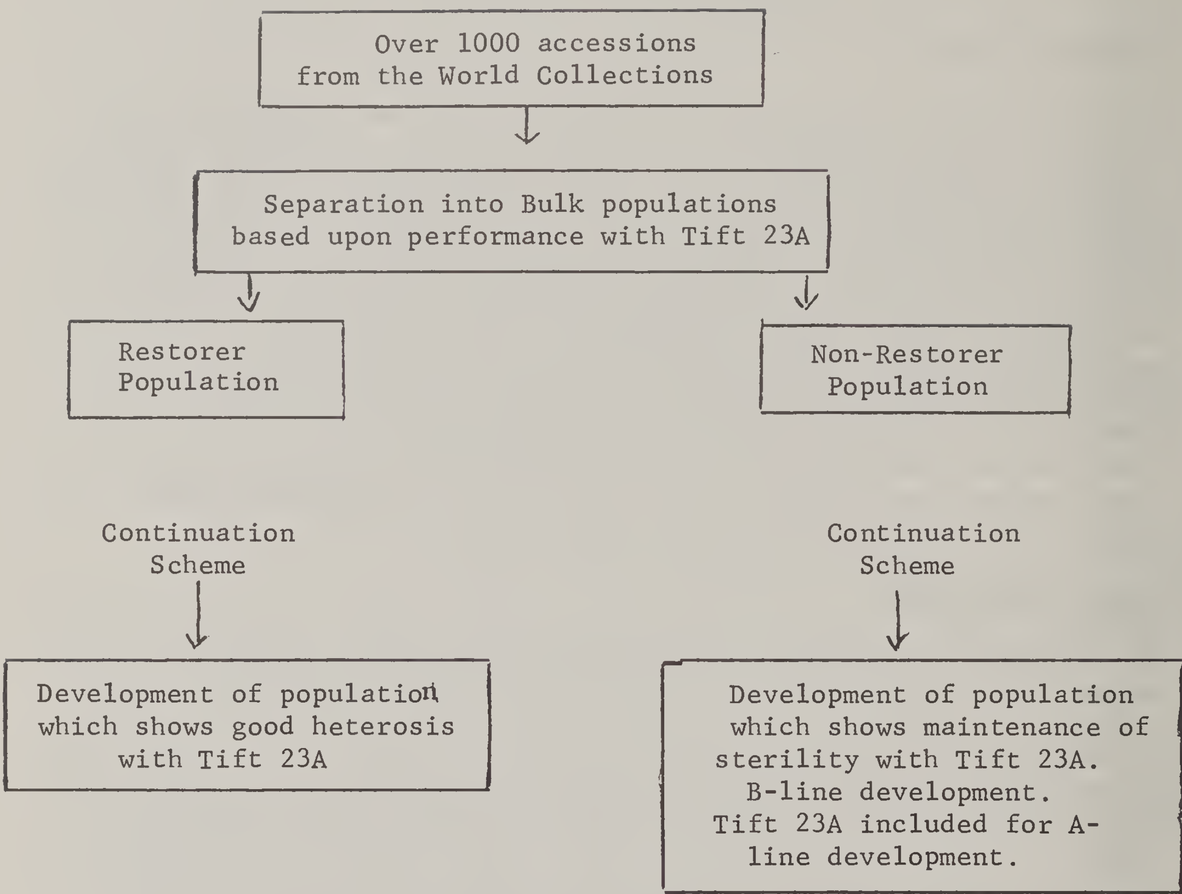

Figure 2. Recurrent selection program for the World Collection of Bulrush Millet.

Development and Testing of Adapted Male-steriles

A bristle strain, Serere 10LA, has been developed and tested. Although complete analyses are not available preliminary information for one season's evaluation indicates hybrids using the strain as the seed parent may be quite well adapted to the area. When the same pollinators were used on Tift 23A and Serere 10LA, the Serere 10LA hybrids yielded over twenty per cent more grain. The paired mating system of backcrossing was carried out in the sterilization and development of the A and B lines of the six additional strains. These are not yet ready for testing.

Recurrent Selection

The second cycle of selection and selfing, and S_1 yield testing of the Serere Population, as discussed and illustrated in Figure 3 was carried out as planned during the first and second rain seasons of 1969. Over 4000 individual selections were selfed during the first rain season. S_1 yield testing was carried out on 1815 selections in fifteen 11 x 11 lattice trials during the second rain season. Using remnant self seed, recombination of the top 180 entries is being carried out in wire cages with irrigation during the 1969-70 dry season. Although selection pressure has initially been for grain yield, grain quality (especially protein) will be included in the next cycle. As it is only possible to carry out the S_1 yield testing at Serere, it is hoped that adequate self seed can be attained so that two dates of planting can be made in the 1970 tests, thus subjecting the selections to a wider range of environmental conditions. Selection for high protein content will also be included in the next cycle. Preliminary results show bulrush millet to be relatively high in protein with lysine and methionine content being higher than in most cereals.

Mass selection for the bristle and non-bristle types was continued. There were five new populations started in 1969. Specific characteristic differences of these are maturity, height, head size, and head type. These populations will form a major nucleus of our breeding and improvement program.

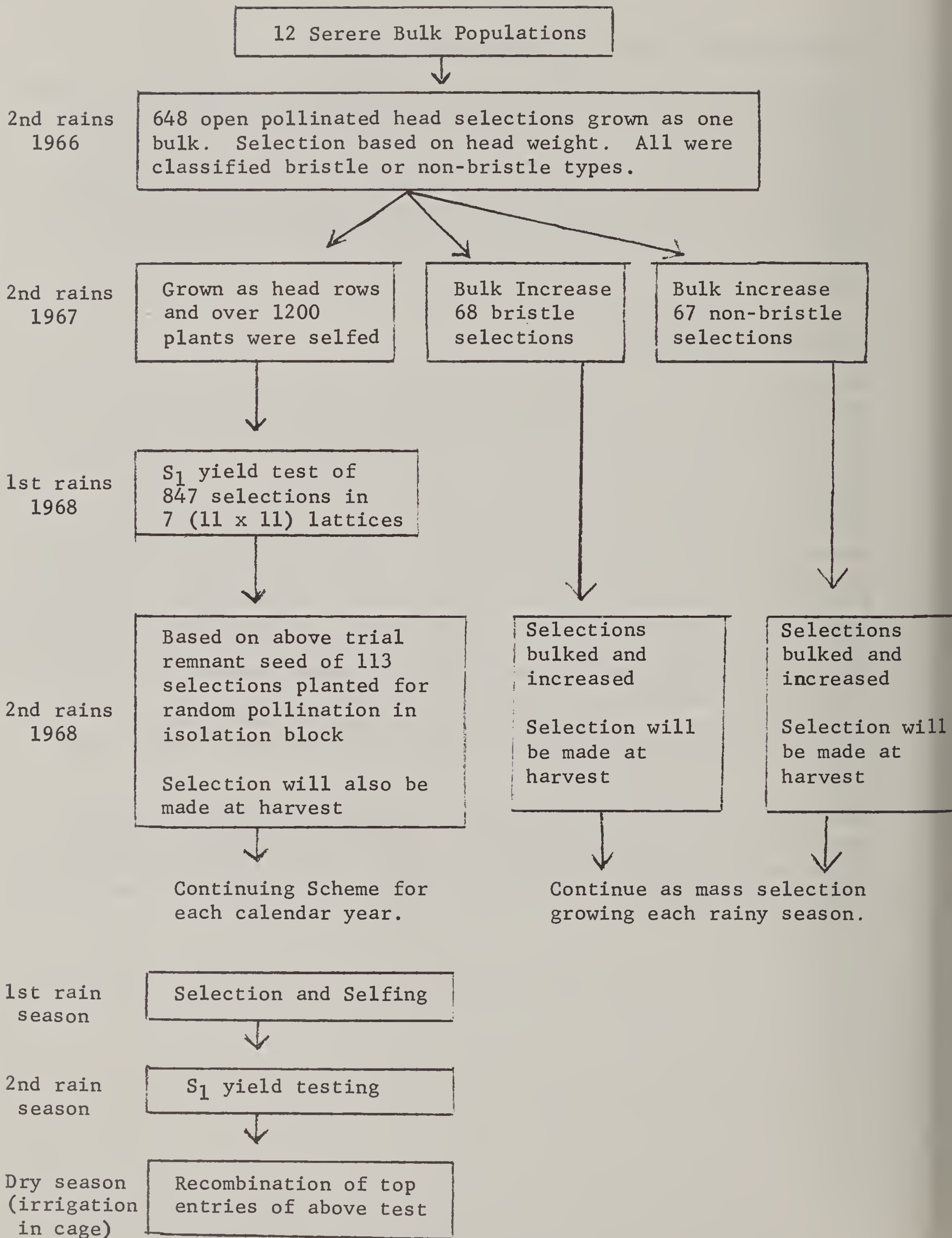

Figure 3. Recurrent selection program for Bulrush Millet

Table 56. Grain yields in kg/ha from the Regional Finger Millet Variety Trials, First Rains 1969.

Varieties	UGANDA									
	Kaber-	Teso District					Busoga District		Lango District	
	amaido	Kuju	Aropai	Kumi	Bukedea	Serere	Vukula	Bagaya	Aduku	Ngetta
Serere 104	5360	2680	3070	1640	2240	2150	1730	1590	3220	1960
Serere 1	5910	2920	2900	2120	2520	1910	1840	1540	3180	1450
Serere 116	5580	3560	2870	1900	2280	2160	1580	750	2890	2330
Eding	4900	2530	2890	1690	2510	2040	1640	890	2850	1790
Serere 358	4110	2900	2890	1710	2410	1920	1860	1230	3150	2110
Gulu E	5100	2980	2850	1540	2510	2150	1750	1190	2730	2120
Engeny	4700	3290	3300	1540	2360	2090	1790	670	2930	2210
Engom	4510	2920	2590	1850	2440	2290	1710	1410	3020	1570
Serere 148	4470	2320	2670	1600	2360	2200	1900	850	3340	2390
Serere 12	4990	2610	2740	1640	2560	2280	1830	1100	2970	1580
Okiring	4120	2100	3400	1120	2540	1960	1950	1630	3020	2130
Serere 101	4000	2810	2470	1910	2620	2420	1760	250	2970	2210
Serere 149	4590	2520	2830	1490	2390	1830	1810	940	3140	1810
Serere 82	4510	2620	2880	1180	2310	2180	1710	1320	3060	2030
Elaba	4550	2390	2570	1720	2520	1770	1580	1010	2770	1980
Serere 312	4320	2390	2980	1210	2250	1760	1610	1290	2770	1890
Serere 66	4490	2420	2520	1600	2340	2010	1910	870	3140	1470
Serere 117	4220	2030	2940	1500	2440	1950	1820	910	2770	2020
Serere 21	4010	2080	2970	1360	2540	2110	1630	1260	2770	2460
Serere 91	4390	3090	2590	1500	1930	2100	1630	830	3020	1910
5 Ex 12 P_1	3840	1880	3040	1030	2200	2080	1660	620	3140	2250
Serere 119	4760	2460	2360	2080	2660	1980	1600	1210	2810	910
5 Ex 12 P_5	4310	1950	2740	1200	2290	1690	1680	870	2970	2510
5 Ex 13 P_6	4170	2530	2610	1050	2340	1830	1690	670	2970	2560
Serere 152	4050	2190	2160	1810	2510	1980	1510	1310	2770	1310
Site Mean	4560	2570	2790	1560	2400	2030	1730	1050	2980	1960
L.S.D. (.05)	810	680	610	450	340	n.s.	n.s.	n.s.	n.s.	480
C.V.(percent)	15.37	22.99	18.94	25.07	12.33	19.90	22.94	78.51	12.02	21.44

Table 56. (Cont'd.) Grain yields in kg/ha from the Regional Finger Millet Variety Trials, First rains 1969.

Varieties	UGANDA								
	Acholi District	West Nile District		Karamoja District		Bukedi District		Buganda District	Entry mean
	Labora	Abbi	Nebbi	Iriri	Namalu	Kibale	Tororo	Namulonge	
Serere 104	3810	3220	370	5060	3460	1470	1100	3410	2640
Serere 1	3800	2360	690	3770	2850	2030	2010	3200	2610
Serere 116	3350	2650	650	4010	3670	1200	1890	3090	2580
Eding	3980	2810	490	3370	2850	1530	3190	3270	2510
Serere 358	4200	2890	490	3920	3060	1460	850	3340	2470
Gulu E	3740	2490	730	3080	3060	1690	1860	2900	2470
Engeny	3540	2610	810	2840	2850	1500	1890	2990	2440
Engom	3750	2400	450	3680	3060	1300	1720	3150	2430
Serere 148	3360	2890	610	3650	3460	1490	740	3080	2410
Serere 12	3640	2650	530	3040	3260	1570	1180	3070	2400
Okiring	4110	3020	650	2110	3060	1570	1080	2860	2360
Serere 101	3860	3380	650	2260	3260	1910	780	2920	2360
Serere 149	3700	2930	570	2690	2650	1540	1780	2990	2340
Serere 82	3630	2610	530	2470	3060	1560	1190	2860	2320
Elaba	3860	2890	570	2770	2850	1460	1410	2780	2300
Serere 312	3840	2890	450	2420	2850	1570	1830	2970	2290
Serere 66	2970	2650	490	3630	3260	1350	1320	2670	2280
Serere 117	3610	2890	770	2780	2650	1560	830	2640	2240
Serere 21	3520	2730	530	2030	2650	1460	1280	2690	2230
Serere 91	3220	2360	690	2370	2650	1260	1570	2610	2210
5 Ex 12 P_1	3800	3220	570	2920	3060	1370	430	2730	2210
Serere 119	3060	1790	240	3090	2850	930	1400	3270	2190
5 Ex 12 P_5	3450	2970	450	2600	2650	1540	850	2440	2180
5 EX 13 P_6	3500	3340	410	2410	2650	1260	270	2390	2150
Serere 152	3320	2240	240	2180	2850	1020	1330	2950	2100
Site Mean	3620	2760	550	3010	2980	1470	1350	2930	2350
L.S.D. (.05)	450	640	230	n.s.	n.s.	360	1230	420	230
C.V. (percent)	10.78	20.11	36.14	47.83	25.91	20.96	78.83	12.29	

Table 57. Grain yields in kg/ha from the Regional Bulrush Millet Trials, Second Rains 1968.

Entries	UGANDA								
	West Nile District		Madi District	Acholi District			Lango District		Busoga District
	Abbi	Nebbi	Pakelle	Labora	Kitgum	Patongo	Aduku	Ngetta	Bugaya
Varieties									
Serere 2A	3610	2380	1030	2170	960	1210	2440	1450	5770
Serere 3A	3520	2260	870	2290	870	1210	2700	1210	5240
Serere 6A	3760	2270	990	2530	1010	1350	2310	1470	5240
Serere 17	3060	2240	940	2310	750	1350	2530	1440	4980
Serere 26/9	2310	2210	940	2630	1200	920	1560	1030	5230
Serere 26/19	2290	1950	820	1730	730	990	2510	840	5290
Serere Farm Bulk	2500	3150	990	2460	930	910	2140	1230	5240
P. maiwa	2360	2600	1030	2260	840	1330	2240	1440	5320
Hybrids									
Tift 23A x Serere 2A	2970	2620	1180	2750	950	1080	2720	1380	5670
Tift 23A z Serere 3A	3370	3200	1150	2840	1100	1370	3230	1540	5450
Tift 23A x Serere 6A	3400	3280	1200	2850	720	1090	2800	1330	5520
Tift 23A x Serere 17	3060	2500	1060	2380	700	1570	2890	1490	5480
Tift 23A x Serere 26/9	2800	2750	1030	2750	850	1110	2680	1610	5720
Tift 23A x Serere 26/19	2740	2120	1060	2850	1000	1010	2910	1280	5670
Tift 23A x Serere Farm Bulk	2630	2670	1180	2430	1020	920	3110	1540	5390
Tift 23A x *P. maiwa*	2670	2870	1090	2090	680	1370	2970	1610	5210
Variety mean	2930	2380	950	2300	910	1160	2300	1260	5290
Hybrid mean	2950	2750	1120	2620	880	1190	2910	1470	5510
Site mean	2940	2570	1030	2460	890	1180	2610	1370	5400
L.S.D. (.05)	780	820	190	610	320	410	670	n.s.	n.s.
C.V.(per cent)	21.08	25.19	14.36	19.61	28.38	27.55	20.36	26.66	8.34

Table 57. (Cont'd.) Grain yields in kg/ha from the Regional Bulrush Millet Trials, Second Rains 1968.

Entries	UGANDA						TANZANIA		Entry mean
	Teso District					Toro District			
	Kabera-maido	Kuju	Arapai	Katakwi	Serere	Kasese	Lubaga	Ukiriguru	
Varieties									
Serere 2A	2430	1040	2090	1880	3070	3590	750	4680	2390
Serere 3A	2640	1010	1450	1710	3200	3160	780	4380	2270
Serere 6A	2610	990	1660	1880	3060	3330	750	4430	2330
Serere 17	2530	1030	1790	1710	3150	3160	760	4550	2250
Serere 26/9	2040	940	1570	1370	2820	2990	840	4430	2060
Serere 26/19	2240	1130	1210	1540	2720	2560	790	3080	1910
Serere Farm Bulk	1980	960	1590	1200	2540	3250	710	4270	2120
P. maiwa	2140	960	1640	1540	2710	2560	740	4430	2130
Hybrids									
Tift 23A x Serere 2A	2280	990	1710	1880	3640	4020	730	4530	2420
Tift 23A x Serere 3A	2530	1130	1500	2050	3710	4270	610	4680	2570
Tift 23A x Serere 6A	2820	1090	1760	1880	3280	3590	800	4050	2440
Tift 23A x Serere 17	2370	890	1860	1710	3330	3420	620	4480	2340
Tift 23A x Serere 26/9	2830	1110	1710	2050	3630	3500	680	4140	2410
Tift 23A x Serere 26/19	2230	790	1660	1540	3610	3930	730	4090	2310
Tift 23A x Serere Farm Bulk	2700	1010	1740	1880	3250	3500	560	4260	2340
Tift 23A x *P. maiwa*	2260	910	1660	1370	2960	3850	560	3850	2230
Variety Mean	2330	1010	1620	1600	2910	3080	760	4280	2180
Hybrid Mean	2500	990	1700	1800	3430	3760	660	4260	2380
Site Mean	2420	1000	1660	1700	3170	3420	710	4270	2280
L.S.D. (.05)	530	n.s.	n.s.	n.s.	550	680	n.s.	630	180
C.V. (per cent)	17.21	18.78	25.66	33.50	13.84	15.68	25.25	11.58	

CEREAL AGRONOMY

G. Schumaker, B. A. Opolot and S. Ogolle

Much of the agronomic work conducted in 1969 was a continuation of studies from previous years. Investigation of optimum time of planting of cereal crops was expanded to include finger millet and bulrush millet besides sorghum. The sorghum date of planting trials included other areas where sorghum is an important crop. Studies to determine the nutrient requirements and optimum levels of application for sorghum and finger millet continued. The Physics and Chemistry Division assisted in soil analysis. Minor element deficiencies were recognized in several districts of Uganda. This resulted in further investigation to determine the nature of the deficiencies. The effectiveness of various herbicides in controlling weeds in sorghum was given further attention. More information was collected in 1969 with regard to the water requirements of sorghum.

Date of planting trials. Late January planting of finger millet did not yield as well as late February planting. Yields were 27.4 quintals/ha from the 24th February date, the variety was Engeny. Rainfall was most favorable from late February through March. The 10th March and 24th March plantings yielded 24.8 quintals/ha and 21.39 quintals/ha respectively and were lower because of low rainfall during the month of April.

The bulrush millet time of planting trial was conducted during the 2nd rains season. Plantings ranged from the period of 27th August through 8th October, occuring at biweekly intervals. Yields from the 27th August and 10th September dates were about equal while those from the 24th September and 8th October showed a distinct decline, yields were as follows:- 36.5, 34.0, 18.5, and 17.1 quintals/ha for the 29th August, 12th September, 28th September and 7th October respectively.

The late August and early September plantings were able to draw from a larger volume of stored moisture than either of the last two plantings. The September and October rainfall was much below normal.

Two sorghum varieties were used in the date of planting trials. Serena and later maturing Dobbs were planted at six different dates over a 12 week period beginning on 26th February. Germination occurred within 5 to 7 days from planting on all six dates studied. The 26th February and 12th March dates were the most suitable times. Rainfall was adequate during establishment and also during the period of grain set in May. Yields of about 35 quintals/ha resulted from planting on either 26th February or 12th March compared to yields ranging from 10 to 20 quintals/ha for the other dates.

A similar sorghum trial was initiated on 7th July for the second rains season. Resistance blocks were installed in the plots of the Serena variety. Blocks were placed to a depth of 90 cm. and were read twice weekly thus indicating when moisture stress occurred. The 26th July date proved to be the best time of planting for both varieties with yields of 49 quintals/ha for Serena and 47 quintals/ha for Dobbs. Yields for the 1st September and 15th September dates were poorest due to continued dry weather during establishment although all planting dates were under soil moisture stress for a part of their growing period.

Similar 1st and 2nd rains trials were conducted at Kitgum and Kumi variety trial centers. In general yields of Serena showed the greatest yield decline when planting after mid-March in the 1st rains, and when planting after early August in 2nd rains. Yields of Dobbs were about 25 quintals/ha for the first three dates studied at Kumi. Spraying to control insects and leaf diseases was not as frequent at Kitgum and Kumi. This resulted in no seed set on the 1st September date at Kumi.

Fertilizer trials. A 4^2 factorial finger millet trial was initiated in the first rains with nitrogen and phosphate levels ranging from nil up to 200 kg/ha of each element. Fertilizer levels were purposely high as an attempt to produce maximum yields. Wire supports were provided in the trial in order to prevent lodging of the crop. Rainfall was not adequate during establishment and during the period of grain set. As a result yields were disappointingly low. Nitrogen did not affect yields. A large phosphate response occurred between the nil and 67 kg/ha levels of P_2O_5. Yields were 10.7, 18.1, 19.6, and 20.8 quintals/ha for 0, 67, 132, and 200 kg P_2O_5 respectively. Finger millet yields from the farmers fertilizer trials conducted in Kumi and Ngora counties of Teso District were also quite low due to low rainfall in the 1st rains season. Application of both nitrogen and phosphorus showed significant increases in yield. Mean yields were only 10 quintals/ha at Kumi and 8 quintals/ha at Ngora, however. Most of the trials were planted in late March and early April when the heaviest rainfall of the season usually occurs. 1969 rainfall for this period was the lowest on record.

Studies on the effectant use of nitrogen and phosphate fertilizer and the inter-relationship of these nutrients with optimum sorghum plant population continued at Serere Research Station and in Kumi county in the 2nd rains season. Plant populations ranged from 54,000 plants per ha. to 178,000 plants, per ha. The population over this range did not have a significant effect on sorghum yields, however. Average yields from nitrogen and phosphate application for the 1st and 2nd rains seasons for 1968 and 1969 are shown in figure 4.

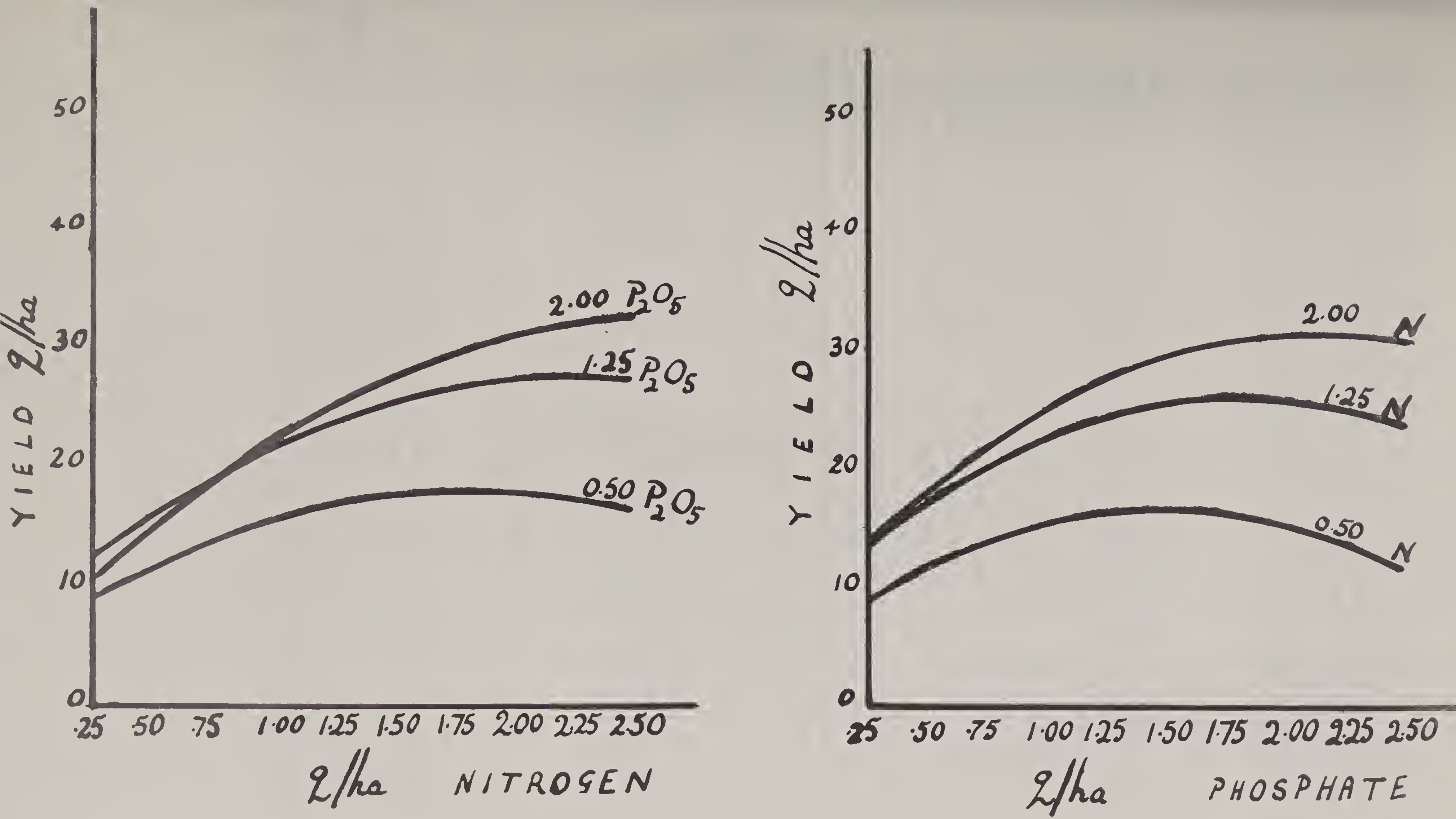

Figure 4. Average sorghum yields in quintals per hectare for sorghum fertilizer trial for 1st and 2nd rains seasons 1968 and 1969. Left: Sorghum yields with increasing levels of nitrogen for three phosphate applications, .5, 1.25, and 2.00 quintal P_2O_5 per ha. Right: Sorghum yields with increasing applications of phosphate for nitrogen applied at three different levels.

A fertilizer plant population trial with maize was conducted at Serere and at Aduku variety trial center, Lango District. Two hybrids were used, H-511 and a longer maturing hybrid H-632. At Serere phosphate application showed a significant yield response. Plant population did not influence yields, and nitrogen did not produce higher yields.

Micronutrient problems

Signs of minor element deficiencies appeared in the Labora maize trial at about 4 to 6 weeks from emergence. Plots receiving nitrogen were most seriously affected where leaves showed distinct striping. Sulfur, zinc, and Magnesium deficiencies are often exhibited in this manner. Leaf analysis data taken at silking showed a high N/S ratio in samples from the 125 kg/ha N only treatment and indicates that the soil was unable to supply additional sulfur which was required when nitrogen was applied. The single superphosphate used contained sulfur and the deficiency was not apparent when both calcium ammonium nitrate and single superphosphate were applied together. The nil treated plots showed no visual signs of deficiency, however, the nutrients required to produce a crop of 2.3 quintals/ha would be very small.

Leaf striping also appeared in sorghum plots in Kumi and Ngora counties. Deficiency symptoms were most apparent on nil and phosphate only plots. The very low zinc content from the 90 kg/ha P_2O_5 treatment may be an indication of zinc deficiency. More detailed studies are planned in order to determine the nature of the deficiencies at these sites.

The assistance of the U.S.D.A./A.R.S. soils laboratory at Ft. Collins, Colorado is acknowledged. Dr. John Reuss of Colorado State University, Ft. Collins, Colorado also gave valuable assistance in the interpretation of the leaf analysis data.

CEREAL ENTOMOLOGY

B.D. Barry, Assisted by C.D.Muhwana, P.A.Opolot, and J.W. Etengu

During 1969 the entomological research was continued at Serere Research Station with primary interest in developing resistance in sorghum to the two major insect pests of the area. These are the sorghum shoot fly, *Atherigona varia* soccata Rond., and the lowland stem borer, *Chilo partellus* (Swinhoe). The work concerning the sorghum shoot fly has progressed satisfactorily while that concerning the lowland stem borer has been hampered by the lack of a technique for rearing large numbers of the insect in the laboratory for artificial infestations.

Sorghum shoot fly. The sorghum shoot fly, probably the most important insect attacking sorghum in the area has received more attention than other problems. Consequently, more progress has been made in developing resistant sorghums. This can be primarily attributed to a technique of providing heavy populations of insects for screening purposes developed by Dr. K. J. Starks and the development of various lines of sorghum by Dr. H. Doggett which have been selected in the presence of shoot fly infestations.

Areas of Work

Recovery resistance (tolerance) in Sorghum to the Shoot Fly: Work in this area in the second rains consisted of six screening trials. All of the plots were fertilized with 200 pounds of single superphosphate and 200 pounds of calcium ammonium nitrate. The trials were treated with one pound of actual D.D.T. per acre during the boot stage for stem borer control, except one trial which was a combination screening for shoot fly and stem borer resistance. The experimental area had a high induced infestation of shoot fly by early planting of borders of CK 60 and an application of meat meal to all plots.

A selection scale was devised by adding the percentage of plants having dead hearts to the percentage of plants recovered (producing good heads which would mature within a period of about 10 days) and subtracting 100. Any lines which gave a rating of 33 or more were selected. As the lines progress the selection point of the scale will be increased.

The first trial, replicated three times, included 207 lines which were S_2's and had been previously selected for recovery resistance to the shoot fly. The purpose was to select the best performing lines for further selection and to introduce male-sterility for future work.

Eighty-three lines (Table 58) were selected for further evaluation in a recurrent selection program.

Table 58. A list of 83 lines selected from a total 207 for recovery resistance to the sorghum shoot fly.

Line	Rating	Line	Rating	Line	Rating
1-P-4-1	42.4	35-P-2-1	53.8	165-P-6-2	53.3
2-P-2-1	38.6	37-P-3-2	41.1	165-P-6-1	44.3
2-P-1-2	38.4	37-P-2-1	54.2	165-P-4-1	40.5
3-P-5-1	41.2	37-P-1-1	37.4	170-P-1-2	43.9
3-P-1-1	58.7	38-P-3-2	51.1	208-P-4-2	45.7
7-P-1-2	41.2	39-P-4-2	47.0	208-P-5-2	44.6
7-P-1-1	39.8	45-P-2-2	55.8	209-P-2-2	33.6
12-P-1-2	41.4	45-P-2-1	35.1	210-P-5-1	46.0
14-P-4-2	57.4	48-P-1-1	46.3	210-P-5-2	33.3
14-P-6-2	33.3	50-P-2-1	42.6	210-P-4-2	42.3
14-P-6-1	37.4	71-P-1-2	33.2	210-P-4-1	51.4
14-P-3-2	55.7	71-P-2-1	38.1	211-P-3-1	47.3
15-P-1-1	57.9	71-P-2-2	46.3	211-P-2-2	50.3
15-P-1-2	50.0	78-P-2-2	48.5	211-P-1-2	51.9
19-P-1-1	55.1	82-P-2-2	40.5	211-P-3-2	50.3
24-P-4-2	57.5	102-P-4-1	41.0	217-P-1-2	40.9
24-P-4-1	37.1	102-P-3-1	39.6	218-P-3-2	46.0
25-P-3-1	58.4	107-P-6-1	44.2	219-P-1-2	53.3
26-P-2-1	66.4	135-P-5-1	34.8	219-P-2-2	62.5
28-P-1-1	43.5	135-P-5-2	37.8	219-P-2-1	58.9
28-P-4-1	33.0	135-P-3-2	33.1	224-P-4-2	39.3
29-P-3-1	39.4	137-P-2-2	40.4	228-P-1-2	43.9
29-P-4-2	36.6	143-P-2-1	34.0	231-P-1-2	36.7
29-P-1-1	42.7	156-P-5-1	33.3	234-P-5-1	46.3
31-P-1-2	44.4	156-P-5-2	39.0	234-P-5-2	57.2
31-P-4-1	34.5	157-P-3-1	35.3	236-P-1-1	47.4
33-P-3-2	36.3	165-P-5-2	52.6	236-P-1-2	49.8
34-P-1-2	36.4				
35-P-5-2	43.4				

The second trial, replicated 4 times, consisted of Serena and Namatare plus 55 lines which were originally selected by Doggett from material of a common origin. The original material was crossed to Namatare for the source of recovery resistance, then backcrossed to CK 60 to obtain a short stalk and better grain type appearance. Selections from these were crossed to a range of parents, but only lines crossed with Serena, Namatare, SB 79, and SB 77 were good enough to meet the initial selection requirements. From the 55 lines, 28 were selected (Table 59) for further evaluations as indicated in previous paragraphs. All of the material with SB 77 as a parent was lost in screening.

Table 59. A list of selected lines for recovery resistance to the sorghum shoot fly, which received the original source of resistance from Namatare, plus Namatare and Serena.

Line	Rating	Line	Rating
44-P-1 CK 2 x Namatare	62.7	19-P-1 CK 2 x Namatare	35.4
34-P-1 CK 2 x Namatare	58.0	78-P-2 CK 2 x Namatare	33.2
41-P-2 CK 2 x Namatare	57.8	156-P-5 Serena	51.1
8-P-1 CK 2 x Namatare	57.1	185-P-2 Serena	46.5
70-P-1 CK 2 x Namatare	51.2	164-P-3 Serena	45.4
31-P-1 CK 2 x Namatare	48.9	216-P-1 Serena	42.8
136-P-2 CK 2 x Namatare	48.8	165-P-2 Serena	39.7
82-P-2 CK 2 x Namatare	48.6	183-P-1 Serena	36.4
35-P-5 CK 2 x Namatare	48.2	Serena	36.0
62-P-1 CK 2 x Namatare	41.4	89-P-5 Serena x CK2 x Namat	36.0
27-P-1 CK 2 x Namatare	40.1	208-P-4 SB 79	57.5
36-P-1 CK 2 x Namatare	39.2	161-P-3 SB 79	53.1
15-P-1 CK 2 x Namatare	39.1	157-P-2 SB 79	46.1
45-P-2 CK 2 x Namatare	36.8	158-P-1 SB 79	43.5
Namatare	35.8	219-P-2 SB 79	38.6

The third screening trial included 102 lines plus Serena (recovery) and CK 60 (susceptible) as checks entered 3 times in each of the 3 replications. (The first 4 plants of each plot were artificially infested with *Chilo partellus* egg masses and no D.D.T. was applied in this experiment). Thirty-one selections (Table 60) for resistance to the two insects were made for retesting in 1970.

Table 60. A list of sorghum entries with ratings selected from 102 entries for recovery resistance from shoot fly attack and leaf feeding resistance to the lowland stem borer.

Entry No.	Shoot-fly rating	Stem borer rating	Entry No.	Shoot-fly rating	Stem borer rating
V-2	-	4.0	V-46	35.6	-
V-4	-	4.3	V-58	-	4.7
V-5	35.0	-	V-59	33.3	-
V-6	38.0	4.0	V-61	37.3	-
V-11	-	2.7	V-63	-	4.3
V-17	63.0	4.7	V-64	41.3	-
V-19	42.4	-			
V-20	34.0	-	V-67	57.0	-
V-27	40.0	-	V-69	-	4.7
V-30	33.6	4.3	V-70	42.0	-
CK-60	-	4.7	V-71	38.4	-
V-33	35.3	-	V-73	45.0	-
V-37	37.7	-	V-74	42.6	-
V-39	39.0	-	V-92	35.4	-
V-19	42.4	-	V-99	35.0	-
V-44	34.0	-	V-100	-	4.7
V-45	43.4	-	V-106	34.0	-

A dash means that the rating was not satisfactory for selection for the particular character.

The fourth screening experiment, replicated 5 times, included 17 lines or varieties, which had been indigenous, developed locally, or introduced, for evaluating the rating scheme. The indigenous or locally developed materials, with one exception, SB 77, were classes as having some degree of recovery resistance. Four of the 5 introduced varieties were classed as susceptible. The one exception was Redlan, which in most previous observations has been classed as susceptible (there is no doubt that it is susceptible). Redlan had the lowest rating (most susceptible) in the recovered grouping.

The other two screening trials were concerned with two composite populations from Doggett's breeding program. Approximately 10 percent of the plants with fertile heads (a percentage of the plants were male-sterile) were selected this season. Each population contained approximately 4,900 plants which were arranged in a grid of 25 blocks. Samples were selected from each block to be bulked and seed samples from each population will be used in future studies. During the next cycle only male-sterile plants will be selected.

<u>Primary or Seedling Resistance in Sorghum to the Shoot Fly</u>: Ten IS lines and a check variety, Swarna were submitted from India by Dr. W. Young to be evaluated for shoot fly resistance in Uganda. These were included in an experiment with eight locally available varieties for comparison purposes. All of the IS lines (Table 61) indicated some degree of primary resistance to the shoot fly and were significantly better than the other entries. All ratings were made by calculating the percentage of dead hearts found in each plot.

The grain and head-type of the IS lines are far from being acceptable in the current breeding program in East Africa.

<u>Sorghum Resistance to *Chilo partellus*</u>: One screening test involving CK 60, Dobbs, Serena, SB 79 and ten IS lines from India replicated 4 times produced 104 selected plants which were either resistant or escaped an infestation. All plants were artificially infested with 3 stem borer egg masses per plant (one per plant at 3 different times). Selections (based on leaf feeding) from each material ranged from 2 to 16 (88 plants of each material was highest number possible to select from, but most material had a lower total number plants due to poor germination and accidental loss). All selections will be retested during the next season.

Table 61. Introduced Indian lines of sorghum as compared to local materials in responses to primary shoot fly attack.

Variety	Rep. 1	Rep. 2	Rep.3	Rep. 4	Total	Mean
IS 5072	10	7	13	0	30	7.5 a
IS 5476	12	17	0	8	37	9.2 a
IS 4567	0	20	(18)	(0)	38	9.5 a
IS 5801	13	0	20	14	47	11.8 a
IS 5604	0	9	44	0	53	13.2 ab
IS 4516	25	6	27	0+	58	14.5 ab
IS 1054	0	33	30	0	63	15.8 ab
IS 5383	0	10	33	30	73	18.2 ab
IS 1082	10	40	(32)	(12)	94	23.5 abc
IS 4776	33	60	47	27	167	41.8 bcde
CK 60	54	54	44	44	196	49.0 cdef
SB 79	62	33	67+	75	237	59.2 defg
Dobbs	67	77	67	33	244	61.0 efg
Combine Type II	100	50	100	33	283	70.8 efg
Swarna	100	100	62	25	287	71.8 fg
Namatare	78	83	100	82	343	85.8 g
Totals	564	599	704	383	2,250	

+ Three or less plants.

Numbers in parenthesis were estimated (Yate's Method) for missing data (no seed). Three varieties (White Wheatlan, Serena and L 28) have been omitted from the analysis due to poor germination. Means not followed by the same letter (i.e., a,b,.... g) are significantly different at .05 probability (Duncan's separation).

A second screening test for Chilo resistance was conducted with a composite population from Doggett's breeding program (one of the same populations used in selecting for shoot fly resistance). The selection procedure based on leaf feeding was the same as with the shoot fly except only a population of 1,000 plants (10 blocks) were used and only about 5% of the plants were selected. All plants were infested as in the above test.

Maize Resistance to *Chilo partellus* and *Helminthosporium turcicum*: Fifty-three lines of dent maize from the U.S., which had previously been evaluated as resistant to the European corn borer and blight, *Helminthosporium turcicum*, were tested for resistance to *Chilo partellus* and blight. The blight resistance appeared to be satisfactory under natural conditions, but only 15 lines were rated as resistant to the stem borer. The lines rated resistant to the stem borer could have been escapes since only a limited number of egg masses were available. However, they will be retested and if they continue to be rated resistant, they will be given to the maize breeders at Kitale, Kenya and Kawanda, Uganda.

Sorghum Breeding: All of the IS lines listed in Table 61 were selfed for additional seed and crossed with the locally available materials listed in the table. Also, all of the IS lines were crossed to male-sterile plants from Doggett's two composite populations.

Maize Breeding: Certain lines from the 53 introduced from the U.S. were selfed and some were crossed with an open pollinated material from Ecuador which had been selfed once. However, there was little chance of obtaining good seed from the crosses since the synchronization of pollination was not good, despite varying dates of planting.

Laboratory Rearing of *Chilo partellus*: Attempts have been made to rear *Chilo partellus* on a diet which has been successful for rearing the European corn borer, *Ostrinia nubilalis*, and with many modifications of this diet. To date none of these attempts have been entirely satisfactory. It appears that the diet lacks a feeding stimulant or it has a feeding deterrent for the first instar larvae. The regular European corn borer diet (with sorghum leaf whorl meal as a base) and most of the modifications are satisfactory if the freshly hatched larvae are fed fresh sorghum leaves for the first 4 - 5 days. Presently, several new diets are being tested.

CEREAL PROCESSING

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If the utilization of sorghum as food in East Africa is to be increased, varieties should be selected which display quality factors suited for their intended end use from among the seemingly limitless array of sorghums available. Therefore, varieties of sorghum representing a cross section of the available array have been provided to us by breeders for evaluation of these quality factors and determination of the importance of these factors in the different processes that may be used to provide basic food ingredients with popular appeal. It is recognized that other factors (i.e. yield, agronomic characters, resistance to diseases and pests, etc.) in addition to those dealt with here must be considered in the ultimate selection of any variety. Whereas it is recognized that certain sorghum varieties should be capable of local processing by the grower in remote areas, following more or less traditional patterns, the large-scale development of this cereal will ultimately require commercially attractive varieties to be made available to millers and processors in urban areas. With increasing urbanization in this part of Africa, commercial processing of sorghum it would seem must eventually follow the development pattern noted with maize, wheat, and more recently, rice.

Fifteen samples of sorghum were provided to us early in 1969 by Dr. Hugh Doggett of Serere, Uganda. Another sample obtained commercially from the Maize and Produce Board, Konza, Kenya, was added to provide a greater range of types. These samples were partially characterized as follows:

Our No.	Description	Color of seed coat	Endosperm type
1-69	White mtama, M & P.B. Konza	White	Corneous
2-69	CK-60 B	White	Intermediate
3-69	5N x 36/1/2	White	Corneous
4-69	5D x 142/2/4 Bulk	Lt.Brown	Floury
5-69	5D x 145/6	Lt.Brown	Floury
6-69	5D x 18/2/2	Brown	Intermediate
7-69	5D x 157/8	Brown	Floury
8-69	4D x 34/1/4C	Lt. Brown	Floury
9-69	Dobbs	Lt. Brown	Floury
10-69	5ADX	Brown	Sl.Floury
11-69	2AD x 4	Red Brown	Corneous
12-69	SB 79	Lt. Brown	Intermediate
13-69	Tet mixed vs Diploid	Lt. Brown	Corneous
14-69	Tet Bulk I	Red Brown	Floury
15-69	Tet 3 Bulk	Brown	Corneous
16-69	H x 60/7/2A	Lt. Brown	Floury

Proximate analyses were performed on these samples with the results indicated in Table 62.

Table 62. Proximate analyses of sorghum samples.

Our number	Proximate analyses of sorghum samples (in percent dry basis)			
	Protein (N x 6.25)	Fat	Fiber	Ash
1-69	12.3	3.2	2.0	1.8
2-69	11.7	3.4	1.7	1.3
3-69	11.3	3.8	2.9	1.6
4-69	11.2	3.3	2.8	1.7
5-69	11.6	3.9	3.8	1.6
6-69	10.5	3.1	3.1	1.8
7-69	11.8	3.0	3.4	1.6
8-69	11.1	3.3	3.4	2.1
9-69	12.5	3.5	3.3	1.7
10-69	14.0	4.3	1.9	1.7
11-69	13.5	4.1	2.4	1.8
12-69	11.7	3.1	2.8	1.7
13-69	13.8	4.0	2.2	1.7
14-69	12.8	4.6	2.3	1.8
15-69	13.0	4.1	1.9	1.8
16-69	11.5	3.5	2.0	2.2

Two pound portions of each of these sorghum samples tempered overnight at 17% moisture were milled in the Buehler Laboratory mill at the laboratories of Unga Mills under the supervision of Julius Ward, Chief Chemist. The results of these millings are given in Table 63.

Table 63. Milling Yields (%) on Buehler laboratory mill.

Our number	Milling yields (%) on Buehler laboratory mill				
	Flour				
	Break	Reduction	Total	Pollard	Bran
1-69	7.1	41.4 (b)	48.5	35.1	16.4
1-69 (a)	6.2	49.6 (b)	55.8	25.6	18.6
2-69	10.8	40.0	50.8	32.3	16.9
3-69	10.3	47.9	58.2	26.8	15.0
4-69	17.9	41.4	59.3	19.6	21.0
5-69	13.3	30.9	49.2	25.8	25.0
6-69	14.2	40.9	55.1	22.8	22.1
7-69	16.0	38.2	54.2	25.9	19.9
8-69	15.6	38.3	53.9	26.6	19.5
9-69	12.8	38.4	51.2	31.2	17.6
10-69	11.4	42.0	53.4	29.8	16.8
11-69	12.0	37.6	49.6	31.9	18.4
12-69	11.8	38.2	50.0	30.8	19.2
13-69	9.2	39.2	48.4	34.6	16.9
14-69	11.0	39.4	50.4	31.5	18.1
15-69	11.7	37.2	48.9	31.0	20.1
16-69	12.4	35.6	48.0	28.0	24.0

(a) Tempered to 19% moisture
(b) Two passes through reduction rolls

Because a fixed milling procedure was used the percentage of break flour would seem to be a reasonable measure of the flouriness or corneousness of the endosperm. Low percentage of break flour are obtained from corneous types and high percentages from floury. Yields of the fractions were somewhat influenced by the glume content of the samples which was quite variable. Bran percentages is affected most directly but all yield figures are affected indirectly. The fiber contents given in the table of proximate analyses (Table 62) are also probably high in some cases because of the tightly adhering glumes.

The flours from all samples were somewhat off white. Those from white seed-coated varieties tended to be off in a yellow direction, those from dark seed coated varieties in a red direction.

The milling fractions of the sixteen sorghums were analyzed for protein (Kjeldahl nitrogen x 6.25). The protein shifts that occurred are shown in Table 64, "Protein Balance Between Grain and Milled Fractions."

The overall protein balance (comparison of last two lines in table 64 was quite good in view of the somewhat incomplete recovery of the milled fractions. Similar shifts to those found for the roller milling of wheat are evident in the table. The protein content of the flours were much lower than the starting grain. However, there are substantial differences between samples. No. 1-69 (Konza sorghum) showed the best retention of protein in the flour with a ratio of percent of total protein in total flour/% yield of total flour equal to 0.82 (a value of 1.00 of course would indicate a protein content of flour equal to that of the whole grain). Konza is unusual among this lot. It is very flinty and required two reduction millings to provide the yield shown, 48.5%, which is well below average. Sample No. 9-69 (Dobbs) with a ratio of 0.78 would be next by this criterion and it provides flour in somewhat better yield. A good sound performer was found to be No. 4-69 (5 x 142/2/4 Bulk) with the third highest ratio of 0.77 with the highest yield of all 59.3%. Interestingly, this sample also showed the largest amount of break flour and was third from the lowest in protein content of the grain.

But many other factors must be considered. Flour color has not been dealt with here. Flinty samples, while they require more power to reduce the grain to flour size, may produce flours that perform better on the silks. We hope to be able to show what changes occur in protein quality, also an important factor.

Table 64. Protein balance between grain and milled fractions.

	Protein balance between grain and milled fractions							
	1-69(a)	2-69	3-69	4-69	5-69	6-69	7-69	8-69
Flour								
Break								
Yield %	7.1	10.8	10.3	17.9	13.3	14.2	16.0	15.6
Protein %	7.44	5.07	5.10	5.17	4.75	5.19	6.04	5.05
Protein amt.	0.53	0.57	0.53	0.93	0.63	0.74	0.97	0.79
Protein % of total	4.8	5.6	5.6	9.7	6.3	7.9	9.5	8.4
Reduction								
Yield %	41.4	40.0	47.9	41.4	35.9	40.9	38.2	38.3
Protein %	9.28	7.06	7.18	8.41	7.54	6.86	8.59	7.06
Protein amt.	3.84	2.82	3.44	3.48	2.71	2.81	3.28	2.71
Protein % of total	34.8	27.7	36.1	36.2	27.1	30.3	32.0	29.0
Total								
Yield %	48.5	50.8	58.2	59.3	49.2	55.1	54.2	53.9
Protein % of total	39.6	33.3	41.7	45.9	33.4	38.2	41.5	37.4
Ratio (b)	0.82	0.66	0.72	0.77	0.68	0.69	0.77	0.69
Pollard								
Yield %	35.1	32.3	26.8	19.6	25.8	22.8	25.9	26.6
Protein %	14.54	13.64	14.14	14.60	15.40	13.64	14.48	14.38
Protein amt.	5.10	4.41	3.79	2.86	3.97	3.11	3.75	3.83
Protein % of total	46.2	43.4	39.8	29.7	39.7	33.5	36.6	41.0
Bran								
Yield %	16.4	16.9	15.0	21.0	25.0	22.1	19.9	19.5
Protein %	9.64	14.01	11.82	10.98	10.75	11.88	11.30	10.36
Protein amt.	1.58	2.37	1.77	2.31	2.69	2.63	2.25	2.02
Protein % of total	14.3	23.3	18.6	24.0	26.9	28.3	22.0	21.6
Total % Protein	11.05	10.17	9.53	9.58	10.00	9.29	10.25	9.35
% Protein in unmilled grain (c)	10.80	10.32	9.81	9.78	10.08	9.13	10.29	9.67

(a) Two passes through reduction rolls
(b) % of total protein in total flour/% yield of total flour
(c) Calculated to weighted average moisture content of mill fractions

Table 64 (cont'd.)

	Protein balance between grain and milled fractions							
	9-69	10-69	11-69	12-69	13-69	14-69	15-69	16-69
Flour								
Break								
Yield %	12.8	11.4	12.0	11.8	9.2	11.0	11.7	12.4
Protein %	5.61	6.75	6.23	5.11	6.73	6.09	8.71	6.92
Protein amt.	0.72	0.77	0.75	0.60	0.62	0.67	1.02	0.86
Protein % of total	6.7	6.4	6.3	5.8	5.1	5.6	9.0	8.3
Reduction								
Yield %	38.4	42.0	37.6	38.2	39.2	39.4	37.2	35.6
Protein %	9.25	9.12	8.50	8.38	9.55	8.88	7.98	8.12
Protein amt.	3.55	3.83	3.20	3.20	3.74	3.50	2.97	2.89
Protein % of total	33.3	32.0	26.9	30.7	30.6	29.5	26.3	27.9
Total								
Yield %	51.2	53.4	49.6	50.0	48.4	50.4	48.9	48.0
Protein % of total	40.0	38.4	33.2	36.5	35.7	35.1	35.3	36.2
Ratio (b)	0.78	0.72	0.67	0.73	0.74	0.70	0.72	0.75
Pollard								
Yield %	31.2	29.8	31.9	30.8	34.6	31.5	31.0	28.0
Protein %	15.63	16.87	16.81	15.13	16.32	17.00	14.87	15.74
Protein amt.	4.88	5.03	5.36	4.66	5.65	5.36	4.61	4.41
Protein % of total	45.7	42.0	45.1	44.8	46.2	45.2	40.9	42.5
Bran								
Yield %	17.6	16.8	18.4	19.2	16.9	18.1	20.1	24.0
Protein %	8.63	13.91	14.00	10.13	13.25	12.88	13.29	9.20
Protein amt.	1.52	2.34	2.58	1.94	2.24	2.33	2.67	2.21
Protein % of total	14.2	19.5	21.7	18.6	18.3	19.6	23.7	21.3
Total % protein	10.67	11.97	11.89	10.40	12.25	11.86	11.27	10.37
% protein in unmilled grain (c)	11.01	12.19	11.94	10.28	12.08	11.27	11.36	10.10

(a) Two passes through reduction rolls
(b) % of total protein in total flour/% yield of total flour
(c) Calculated to weighted average moisture content of mill fractions

The principal gain in protein is in the pollard. Bran in general shows a slight increase but in a few instances the protein content of the bran is even lower than that of the whole grain. The performance of the sixteen sorghum samples through the rice polisher was studied using standard settings for feed gate opening, spacing between screen and abrasive cone, and weight on discharge gate. All bran and product were collected and the product screened through 8-, 10- and 20- mesh sieves. The on 8- mesh fraction contained only the whole kernel. The through 20- mesh was added to the bran.

Table 65. Yields of products on the CeCoCo rice polisher

	Yields of products on the CeCoCo rice polisher				
Our number	% whole on 8 mesh	% on 10 mesh	% on 20 mesh	% Bran	% Recovery
1-69	75.3	11.2	1.7	8.8	97.0
2-69	57.9	17.8	4.7	14.6	95.0
3-69	26.3	31.5	19.3	17.9	95.0
4-69	76.6	8.5	3.7	11.3	100.1 (?)
5-69	72.6	8.9	4.3	12.7	98.5
6-69	59.2	15.7	8.7	13.6	97.2
7-69	83.8	1.5	5.4	6.9	97.6
8-69	72.6	9.5	2.2	11.2	95.5
9-69	51.5	15.6	6.6	21.9	95.6
10-69	62.2	13.1	6.7	14.0	96.0
11-69	64.6	11.8	6.1	13.9	96.4
12-69	69.6	9.8	3.7	13.6	96.7
13-69	72.9	9.7	4.9	9.9	97.4
14-69	65.8	12.8	4.5	13.7	96.8
15-69	74.1	9.6	3.7	10.7	98.1
16-69	34.8	15.5	18.6	23.6	92.5

Almost all of the samples were largely decorticated, if by that we mean removal of the pericarp. In all cases this removal was estimated at 90% or more from inspection of the "on 8- mesh fraction" except for numbers 1 (85%), 4 (80%), 7 (75%), 8 (80%), 12 (80%). However, everyone of the samples, 4 through 16 were brown, mottled with white spots where the testa had been removed. In many cases the color of the decorticated product was even darker than the original because the testa, now exposed, was darker than the pericarp.

Considerable differences in handling characteristics among these sorghums is evident. It is possible that the "% on 8- mesh" may be used as a guide perhaps similar to head yield in rice. Number 3 and 16 are examples of sorghums which are apparently easily broken. In number 3 while the "% on 8-mesh" is lower than for number 16 most of it remains in the larger particle sizes. Number 16, on the contrary, when it breaks produces finer particles, largely. Number 7 is an interesting sample at the other extreme of "% on 8 mesh". This seems unusual because it was judged to have floury endosperm and milling in the Buehler showed that it produced a very high percentage of break flour. Of course it was judged to have been only 75% peeled, the poorest of the lot, and this may mean it has a rather tough pericarp or somehow resists abrasion.

The most attractive polished whole grain product was obtained from 1-69 (Konza) and in very good yield. White seeded varieties with flinty endosperm perform best in the rice polisher and provide the most attractive products.

A wet skinning procedure for sorghum grain was described by J. E. Freeman and S. A. Watson, in "Peeling Sorghum Grain for Wet Milling", Cereal Science Today, February 1969, pp. 10-15. It was decided to try to apply it to the series of varieties under study. The procedure worked fairly well on the white seeded varieties with flinty endosperm but this did not seem to be of great value because such varieties performed very well in the polisher where the process is simpler. However, if it could be applied to the dark seeded varieties that would be advantageous because dark varieties do not perform well in the polisher. So the samples 4-69 through 16-69 were treated according to the following scheme:

200 g. sample were stirred with 30 mls. of 20% caustic soda solution and allowed to stand 15 minutes at room temperature. Then 400 mls. of water at 70°C, was added, mixed, and the mixtures transferred to the Waring Blendor fitted with rubber covered paddles. Stirring at 3,000 rpm for five minutes followed, and the skins and fines were floated off by upward water current in a tall beaker. The grain was air-dried for 24 hours and weighed.

Grain yields and comments are listed in Table 66.

Table 66. Results on wet (Lve) Peeling.

Sample	Grain Yield %	Comment
4-69	74.0	Bran removed, but colored testa remained
5-69	76.0	"
6-69	73.5	"
7-69	69.0	"
8-69	56.5	"
9-69	88.5	"
10-69	72.0	About 50% of pigmented testa removed
11-69	79.0	"
12-69	86.0	Bran removed, but colored testa remained
13-69	73.5	"
14-69	74.0	About 50% of pigmented testa removed
15-69	57.5	Almost completely peeled
16-69	41.0	Bran removed, but colored testa remained

Though the outer bran layer can be removed from these grains by wet peeling procedures, the colored testa where present remains firmly attached to the endosperm. The germ was not readily removed by this system of peeling and darkening of the area containing the germ was marked when alkali was used in the process. Thus wet peeling systems have not yet been found effective in overcoming the milling probelms of grain having colored testa.

Therefore, it would appear that the wet skinning method cannot be applied advantageously in the production of a whole kernel polished or skinned sorghum.

The laboratory at Unga Mills has run milling tests with their Buehler Laboratory mill on a number of other samples of sorghum. A quantity of CK-60B was provided by Dr. Kenneth Starks, Serere, Uganda, and this was experimentally roller milled. Sorghum CK-60B is an entirely white seed-coated variety, without testa, of intermediate corneousness with dark glumes. In this sample a fair proportion (10-20%) of the grains had tightly adhering glumes. Also this sample showed evidence of insect damage which causes the bleeding of the pigment in the glume into the seed-coat and endosperm. This sample was milled without cleaning. The yields of milling fractions obtained on a sample tempered to 17 percent moisture are given in Table 67.

Table 67. Yields of Milling Fractions from Sorghum CK-60B

Fraction	Percentage	
Flour		45
Break	9	
Reduction	36	
Pollard		31
Bran		22
Losses		2

The composition of the fractions are given in Table 68.

Table 68. Sorghum CK-60B Proximate Analyses of milling fractions.

	Grain	Flour		Pollard	Bran
		Break	Reduction		
% Moisture	15.4	13.7	13.5	12.5	12.2
% Protein (N x 6.25)	8.4	4.7	8.2	13.1	12.8
% Fiber	1.9	0.5	0.4	1.3	10.3
% Ash	1.3	0.4	0.4	0.7	4.4

The low milling yield is in part explained by the use of uncleaned sorghum. This also is reflected in very high fiber content of the bran. This bran is very dark in color because of the presence of the dark glumes. Although CK-60B is a white seed-coated variety its flour is even more pink than that from Serena reported last year. This color is believed to be due to the insect damage noted previously.

We have found to date that the whitest flour by roller milling in the Buehler Laboratory Mill is produced from Sagana sorghum. This sorghum has a white pericarp, but a dark testa and it is not understood why the flour should be as white as it is. It has been suggested that small pieces of testa in the flour may have an eye-deceiving "bluing" effect. Of course it may be that the endosperm is simply whiter.

Before milling quantities of flour from Sagana sorghum for use by the Department of Home Economics, University College, (reported later in this report) the laboratory at Unga Mills made a study of effect of moisture adjustment on yield and color of flour. The results of that study were as follows:

Table 69. The effect of moisture adjustment on yield and color of flour in Sagana Sorghum.

Tempering	Yield of Flour %			Color Values (c)	
Condition	Break	Reduction	Total	Break	Reduction
17 (a)	24.6	37.7	62.3	15.2	17.9
19 (a)	24.1	36.2	60.3	14.4	14.9
17 + 2 (b)	23.8	35.6	59.4	14.9	14.9
19 + 2 (b)	22.8	35.1	57.9	14.7	14.7

(a) Moisture adjusted to this value overnight.
(b) Moisture adjusted to first value overnight, 2% more moisture added one hour before milling.
(c) Kent-Jones & Martin Color Grader Method.

Based on these data it was decided to use tempering to 19% overnight for the millings to produce quantities of flour. The yield at 17% moisture is better but the color poorer. The Kent-Jones & Martin Color Method is not well adapted for sorghum flours but it is the only objective test for color available to us.

We have subsequently analyzed the samples for nitrogen and prepared a balance for protein as was done for the 16 sorghum samples. These results are shown in Table 70. Sagana sorghum apart from the whiteness of its flour, exhibits other extreme milling characteristics when compared with the 16 samples of sorghum previously run. The break flour yield from Sagana was 24.6% at 17% moisture, the same conditions as were used for the 16 samples. Highest among the 16 was No. 4-69 with 17.9% break flour. The total flour yield, 62.3% was somewhat higher than the best of the 16, No. 4-69 with 59.3%. The ratio: percent of total protein in flour/per cent yield of flour is 0.81 for Sagana almost equalling the highest of 16, No. 1-69 at 0.82. This was achieved with Sagana at a higher yield of 62.3% compared to 48.5% for No. 1-69 with two passes through the reduction rolls. Sagana sorghum also has a lower protein content, 9.5% dry basis, then the lowest of the 16, No. 6-69 at 10.5%. The ratio indicative of protein transfer to the flour are higher at 19% moisture, 0.86 and 17 + 2, 0.89 with only small sacrifice in flour yield.

Mr. Ward, Chief Chemist, Unga Mills noted that a sample of sorghum, white seeded with corneous endosperm, from a Nairobi shop was difficult to reduce to flour. It required two passes through the reduction rolls to obtain any reasonable yield of flour. He further observed that a high yield of granulars could be taken after a single pass through the break rolls. Tempering to 19% moisture content provided near optimum conditions for this type of milling.

The yield of fractions were as follows:

Yields of Fractions by Milling of Sorghum from Nairobi Shop
Using Break Rolls Only

Fraction	Percentage
Granulars	63.3
Break Flour	5.1
Bran	31.6

Table 70. Protein balance between grain and milled fractions effect of tempering - Sagana sorghum.

	Tempering conditions			
	17 (a)	19(a)	17+ 2(b)	19 + (b)
Break Flour				
% Yield	24.6	24.1	23.8	22.8
% Protein	4.69	5.21	6.71	5.29
Amt. of protein	1.15	1.26	1.60	1.21
% of total protein	13.7	13.9	18.2	14.3
Reduction Flour				
% Yield	37.7	36.2	35.6	35.1
% Protein	8.16	9.58	8.52	7.78
Amt. of protein	3.08	3.47	3.03	2.73
% of total protein	36.7	38.2	34.5	32.3
Total Flour				
% Yield	62.3	60.3	59.4	57.9
% of total protein	50.4	52.1	52.7	46.6
Ratio (d)	0.81	0.86	0.89	0.80
Pollard				
% Yield	19.7	13.8	11.8	15.8
% Protein	12.51	13.34	13.64	14.13
Amt. of protein	2.46	1.84	1.61	2.23
% of total protein	29.3	20.2	18.4	26.3
Bran				
% Yield	18.0	25.9	28.8	26.3
% protein	9.61	9.88	8.87	8.91
Amt. of protein	1.73	2.56	2.55	2.34
% of total protein	20.6	28.2	29.1	27.6
Total % protein	8.42	9.13	8.79	8.51
% Protein unmilled grain (c)	8.34	8.31	8.46	8.44

(a) Moisture adjusted to this percentage overnight

(b) Moisture adjusted to first value overnight. 2% more added 1 hr. before milling.

(c) Calculated to weighted average moisture content of mill fractions.

(d) % of total protein/% yield.

The granulars are produced in good yield, are nearly white in color and of attractive appearance. These might well be used as farina is used. (Cream-of-wheat in the U.S.A. is an example of a farina product).

The proximate composition of the original grain and the fractions are given in Table 71.

Table 71. Sorghum from Nairobi shop proximate analyses of milling fractions.

	Grain	Break Rolls Only		Bran
		Granulars	Break Flour	
% Mositure	13.5	14.0	13.5	12.6
% Protein (N x 6.25)	10.6	12.1	8.9	13.2
% Oil	3.1	1.2	2.0	3.5
% Fiber	1.6	0.5	0	3.5
% Ash	1.5	0.7	0.9	3.7

Granular products have been produced in the same fashion from two other flinty sorghums, No. 1-69 (Konza) and No. 91-69, Msumbiji acquired for use in the Saba Saba Show reported later. Results of milling and protein balance are given in Table 72.

Table 72. Protein balance between grain and milled fractions (Granulars from Konza and Msumbiji)

Sample	Konza (No. 1-69)	Msumbiji (No. 91-69)
Bran		
Yield %	18.0	15.6
Protein %	9.88	13.16
Amount of protein	1.78	2.05
% of total protein	16.2	19.3
Granulars		
Yield %	75.3	82.0
Protein %	11.63	10.25
Amount of Protein	8.76	8.41
% of total protein	79.5	79.2
Ratio (a)	1.02	0.96
Flour		
Yield %	6.7	2.5
Protein %	7.06	6.46
Amount of protein	0.47	0.16
% of total protein	4.3	1.5
Total % protein	11.01	10.62
% Protein unmilled grain (b)	10.86	10.10

(a) % of total protein/% yield
(b) Calculated to weighted average moisture content of mill fractions

The yield of product is very high at 75.3 and 82.0%. Of course granulars are not entirely clean but they compare favorably with semolina product marketed here. The granular product has a ratio: percent of total protein in granulars/percent yield of granulars of 1.02 for Konza and 0.96 for Msumbiji. In other words the protein content of the flour is very nearly equal to that of the whole grain. In the case of Konza a very slight concentration would be indicated. These sorghums have reasonably high protein contents, 12.32 and 11.69 per cent dry basis for Konza and Msumbiji respectively.

The CeCoCo Rice Polisher has been utilized to produce a whole grain polished sorghum. This milling, for best results, requires a white seeded variety without dark testa and with flinty or corneous endosperm. The Konza variety which has been used before is a good example. Three other such varieties from Tanzania have been found that seem to perform at least as well as Konza. The Msumbiji variety was obtained from Mtwara for demonstrating the operation of the CeCoCo polisher during the Saba Saba Show in Dar es Salaam, Tanzania, July 3 through 7. This is a small seeded variety with somewhat elongated kernels, rugby ball shaped. Its endosperm is almost entirely corneous and its seedcoat is thin and translucent. Another variety, Lionja, was received later. It has a larger seed and is lens shaped, that is almost round when viewed in one direction and relatively thin in the other. In other characters it is similar to Msumbiji. A small quantity of a third variety, a local white grown near Ilonga, is fairly large and its shape is intermediate between Lionja and Msumbiji. That is, rather than being nearly round it is somewhat elongated but is still relatively thin. Again in other characters it is similar to the other two. The size of the kernels may be judged from the following weight data. Konza is included for comparison.

Sample	Average weight for one grain (mg)
Lionja	27.3
Ilonga	26.3
Konza	23.2
Msumbiji	22.2

From the table, it can be seen that the kernels of Lionja and Ilonga on the one hand, and those of Konza and Msumbiji on the other, are nearly of the same size and that there is an appreciable difference between the two groups.

A comparison of their composition is provided in Table 73 giving proximate analyses.

Table 73. Proximate analyses of white flinty sorghums (in percent, as is basis)

Sample	Moisture	Protein (N x 6.25)	Fat	Fiber	Ash
Msumbiji	12.31	10.25	3.35	1.24	1.30
Lionja	11.60	9.19	3.01	1.75	1.60
Ilonga	10.73	11.50	2.97	1.70	2.59
Konza	10.74	11.00	2.85	1.78	1.59

Substantial range of protein contents are displayed here. Ilonga, has the highest protein content but the quantity of Lionja that we obtained was quite small and possibly might not be representative. This will be checked into when a large sample is obtained. A large sample was requested several months ago but receipt has been delayed because of the involved rules concerning the movement of grain from one country to another.

These samples are well threshed in contrast to some of the sixteen samples reported previously. The fiber content is quite low for all these samples, exceptionally low for Msumbiji, compared to the sixteen even when allowance is made for tightly adhering glumes.

Part of the quantity of Msumbiji that had been debranned at the Saba Saba Show was returned to the laboratory. Comparative analyses of Msumbiji before and after polishing were as follows:

Proximate Composition of Msumbiji Sorghum and Polished Msumbiji (in % dry basis)

Sample	Protein (N x 6.25)	Fat	Fiber	Ash
Grain	11.7	3.8	1.4	1.5
Polished	11.4	3.0	0.8	1.3

A very substantial reduction in fiber content was achieved with an almost insignificant lowering of the protein content, a most desirable combination of events. Since the polishing was done at the show, yields were not determined. Now that the Msumbiji sorghum has been returned to the laboratory, well controlled debranning will be conducted to clearly define the protein and fiber balance.

A sampel of polished Msumbiji sorghum made available from that produced at the Saba Saba Show was prepared in various ways by Mrs. A. Joshua of the Research and Training Institute, Ilonga, Tanzania and evaluated by a taste panel assembled from among staff members. Several traditional dishes were evaluated, for example, a combination of cowpeas and green gram and uji and ugali (thin and thick poridge) prepared from flours. In all cases the polished sorghum was preferred to the unhusked product.

Arrangements are going forward to loan a rice polisher similar to one used at the Saba Saba show and ordinarily housed at EAIRO to the Institute at Ilonga for their use. Equally important it would also be for use in the rural areas under their supervision for which a gasoline driven power supply will be provided. Approval for these cooperative activities have been obtained from Mr. G. S. Semiti, Director of Research, Training, and Farmers' Education, Ministry of Agriculture, Food, and Cooperatives, the United Republic of Tanzania and Mrs. A. Joshua and an order for the equipment has been submitted.

Three of these four samples, Konza, Msumbiji and Lionja have been run in the CeCoCo rice polisher and the yields at the indicated settings are shown in Table 74. Similar runs are planned for Ilonga when the larger quantity is obtained.

Table 74. Yields of sorghum fractions from CeCoCo rice polisher.

Sample	% on 8-mesh	% on 20-mesh	% Edible	% Bran & fines	% Recovered
First setting: Discharge weight fully in					
Konza	65.7	18.7	84.4	14.3	98.7
Msumbiji	80.6	11.0	91.6	7.1	98.7
Lionja	74.1	14.7	88.8	8.8	97.6
Second setting: Discharge weight one notch outward					
Konza	66.0	19.1	85.1	14.3	99.4
Msumbiji	79.2	10.7	89.9	7.3	97.2
Lionja	72.8	16.7	89.5	9.3	98.8
Third setting: Discharge weight two notches outward					
Konza	57.4	24.1	78.5	15.7	97.2
Msumbiji	71.6	15.9	87.5	10.4	97.9
Lionja	64.7	21.0	85.7	11.6	97.3

With the control weight fully in the sample received the mildest mechanical treatment. Moving the control weight outward increased the treatment the grain received.

On examination of the cleaned grains it was found that those from the Lionja sample had the best appearance at each of the three settings; Msumbiji and Konza had about the same appearance though not as attractive as Lionja's. This observation may suggest that samples with larger seeds perform better in the polisher.

As far as yields of edible product were concerned, Msumbiji showed the highest percentage yield at each of the three settings followed by Lionja and Konza in that order.

Establishing and maintaining the operation of the Amino Acid analyzer has been fraught with a seemingly unending series of difficulties. Many problems arose beginning with the damage to the electrical and buffer and ninhydrin systems caused by rats and continued right through the year with some heartening and well-remembered periods of good performance. We are hopeful that these periods will predominate henceforth. Mold growth in the buffer should now be eliminated with the provision of a cold storage compartment for buffers and ninhydrin. A visit just completed from the Field Service Engineer brought renewed hope with the establishment of a more positive grounding for the equipment and step-up in voltage output from the transformers.

We have decided on a four hour procedure for amino acid analyses. This gives us the capability of doing two complete analyses per day.

We are developing our technique for preparing hydrolysates of grain for analyses. Preparing the sample for hydrolysis requires the preparation of an evacuated ampule containing sample and 6 N hydrochloric acid. This involves two rather tricky glass manipulations: first, after the sample is weighed into the tube the necking down to provide a point for subsequent sealing off under vaccum, and second, the actual sealing off. Considerable time was spent in the operators gaining some competence in these techniques. Progress has been made and greater skill will come with practice.

Analyses for lysine were run on samples of maize provided by the Maize Breeder at the Research and Training Center, Kilosa, Tanzania, Mr. David Haswell, from his work with the opaque 2 gene. The results were as follows:

Lysine content of maize samples

Sample	Lysine content (mg lysine/16 mg N)
Opaque kernels from bulk in trial 1969	3.9
Normal kernels from some cobs as above	2.2
Kernels from control variety Ilonga Composite	2.6

These results showed at least a 50% higher content of lysine in the protein for the opaque kernels over the normal kernels.

Analyses for amino acids in hydrolysates prepared from Msumbiji original (91-69) and Msumbiji polished (92-69) have been completed and the results from these analyses are shown in Table 75.

Table 75. Amino acid composition of Msumbiji grain sorghum.

Amino acid	Msumbiji original Gm/100 gm. protein	Msumbiji polished Gm/100 gm. protein
Tryptophane	-	-
Lysine	2.41	2.25
Histidine	2.39	2.25
Ammonia	3.00	3.05
Arginine	4.25	4.00
Aspartic acid	7.60	7.97
Threonine	3.65	3.04
Serine	5.56	4.00
Glutamic acid	25.16	22.93
Proline	10.05	11.51
Glycine	3.63	2.86
Alanine	11.20	9.29
Half-cystine	--	--
Valine	5.83	4.64
Methionine	--	--
Isoleucine	4.50	4.12
Leucine	16.49	18.80
Tyrosine	4.47	3.61
Phenylalanine	6.06	5.10
Protein % (N x 6.25), at 12% moisture	10.36	9.96

The method of hydrolysis we use (acid hydrolysis, 110 $\pm$ 1^{o}C, 24 hours) destroys all of the tryptophane, nearly all of the cystine and a large amount of methionine, so values for these amino acids are not reported. The data reported show that polishing has only a minor effect on protein content (3.9% reduction). The essential amino acids show relatively small reductions in lysine, 6.6% histidine, 5.8% arginine, 5.9% threonine, 16.7% valine, 13.9% isoleucine, 8.4% and phenylalanine, 15.6% so that nutritional value of the protein may also be fairly well maintained: The essential amino acid leucine actually showed an increase of 8.0%. Other increases were noted in aspartic acid 4.9% and proline 14%. We had expected glutamic acid to increase, but found a reduction of 8.8%. The greatest change occurred in serine, 28% reduction.

Our results are compared with those found by other workers, are presented in Table 76.

Table 76. Amino acid distribution in protein of sorghum grains.

Amino acid	A % of protein	B % of protein	C % of protein
Lysine	1.42 - 3.14	2.10	2.41
Histidine	1.01 - 2.52	2.24	2.39
Arginine	2.54 - 4.87	3.87	4.25
Aspartic acid	6.18 - 9.95	7.00	7.60
Threonine	3.13 - 3.58	3.33	3.65
Serine	3.53 - 4.91	4.77	5.56
Glutamic acid	23.11 -32.10	22.32	25.16
Proline	7.70 -14.60	8.39	10.05
Glycine	2.27 - 3.89	3.01	3.63
Alanine	10.16-14.02	9.68	11.20
Half-cystine	0.53 - 1.37	2.04	
Valine	4.20 - 6.59	4.96	5.83
Methionine	0.73 - 1.92	1.75	--
Isoleucine	3.68 - 6.20	4.07	4.50
Leucine	12.70- 20.90	13.31	16.49
Tryosine	1.23 - 2.84	4.37	4.47
Phenylalanine	4.56 - 6.62	5.41	6.06
Protein %, 12% moisture, (N x 6.25)		10.10	10.36

(A) T.K.Virupaksha and L.V.S.Sastry from nine varieties, studies on the protein content and amino acid composition of some varieties of grain sorghum. J.Agr.Food Chemic. 16,199 (1968).

(B) D.B.Parish et al for Paymaster - Kiowa Variety amino acid composition and nutritional value of milled sorghum grain products. Cereal Chem. 46, 164 (1969).

(C) EAIRO Msumbiji Variety.

Table 76 shows that the percentages that we obtained lie in an intermediate position on the range of values in (A); of particular interest are the values for the essential amino acid lysine, histidine, arginine, theonine, valine, isoleucine, leucine and phenylalanine. Their values are reasonably high and seem to indicate that the Msumbiji variety may have higher nutritional status than sorghums which have been studied elsewhere.

Cooperative arrangements were made with the Home Economics Department, University College, Nairobi, to evaluate sorghum products developed in our laboratory and to develop recipes using them. A Third year student was hired during the three-month summer recess. She was supervised by a regular member of the staff. Quantities of pearled white sorghum, whole kernel and cracked, produced in the rice polisher, and granulars (semolina) and flour produced by roller milling at Unga Mills were provided to them for this study.

Many dishes were tried, modified and tested. Thirty-three recipes were judged to be worthy and have been compiled into a booklet. Ten recipes are in the appetizer and dessert category, and include soups and puddings. Another ten are classed as main dishes and include simple breads, meat substitutes, casseroles and a salad. There are thirteen recipes which may be used as tea and coffee accompaniments. These include cakes, short breads, scones and sweet breads. The recipe booklet will be made available to interested local people.

The student hired for this work with some colleagues and two members of the Home Economics faculty demonstrated at the Nairobi show (first week in October) sorghum recipes developed under this project. They were in the East African Industrial Research Organization booth and demonstrated ugali from sorghum semolina, sorghum cake from sorghum flour, rice-style sorghum from cracked polished sorghum, and sorghum and cowpeas using whole polished sorghum. Small portions of the product were distributed to the crowds. Reactions were in general favorable.

Beginning in February 1970, another student has been hired to work at the Home Economics Department determining cooking characteristics of the sixty samples of sorghum provided by Dr. Hugh Doggett of Serere, Uganda. The first evaluations are to be done on the whole sorghums. A standardized cooking procedure is being used and water absorption, cooking rate, flavor and texture are being evaluated. Other standardized tests on other sorghum products are contemplated in order to show additional differences in cooking characteristics between the various sorghum.s

Sorghums, where the quantity of sample is large enough will be milled in the Buehler Laboratory Mill at the Unga Mills Laboratory to produce flours, and in the CeCoCo rice polisher to produce polished whole kernel and cracked products.

Mr. Julius Ward, Chief Chemist at Unga Mills has undertaken a preliminary experimental re-milling of wheat pollard to produce a protein concentrate after the fashion described in Cereal Chemistry 42:715-725(1966) and 45:520-529 (1968). In a preliminary effort pollard was dried to 6.4%

moisture and passed once through the Quadramat Junior Mill. Three fractions were recovered: fine flour, 60%; low grade flour 20%; and bran 20%. The analyses of these fractions are listed in Table 77.

Table 77. Analyses of fractions from re-milling of wheat pollard.

Sample	% protein (N x 6.25)	Ash	Fiber
Fine flour	18.1	3.18	5.2
Low grade flour	15.4	3.66	9.0
Bran	14.8	4.39	11.8

These results are encouraging because they indicate that desirable protein increases and simultaneous fiber decreases are possible by re-milling this local wheat by-product as was observed in U.S. wheats in the references cited. Actually even greater shifts would be expected with a less dry product (optimum was about 10% moisture in the literature citation).

Another re-milling of wheat pollard was performed at the Unga Mills laboratory in the Quadrumat Junior Mill. This time the moisture was adjusted by drying to 9.7% very near the optimum found previously in the referenced work. Three fractions were recovered: high grade flour 40%, low grade flour 8%, bran 50% and 2% loss. The analyses of these fractions and the original pollard are shown in Table 78.

Table 78. Analyses of fractions from re-milling of wheat pollard.

Sample	% Protein (N x 6.25)	% Ash	% Fiber
High grade flour	20.7	3.1	3.4
Low grade flour	18.4	3.5	7.1
Bran	14.9	4.2	10.8
Pollard (original)	17.8	3.6	7.4

The high grade flour was further fractionated by screening through 10 xx silk.

Throughs amounted to 36%. This was analyzed for protein and ash content which were found to be 18.6% and 2.5% respectively. By calculation, the remaining 64% of the fine flour would have a protein content of 21.9%. This would be obtained in about 26% yield from pollard. The fiber content is somewhat high compared to values found in the referenced work. Nevertheless, these results are encouraging because they were obtained in the Quadrumat Junior Mill and better results would be expected if the Quadrumat Senior Mill were used as in the referenced work.

Wheat protein concentrate, WPC, as this product from remilled pollard ("shorts" in U.S.) has been called in the United States, provides an ingredient for two nutritions food products, wheat-soy blend, and flour blend A, which are used in the US export food distribution program. A similar product might well be useful in East Africa. From these experiments, it would appear that such a product is possible from indigenous materials.

The Udy analyzer has been used to provide estimates of the protein content of samples from sorghum and finger millet trials conducted by Mr. Gilbert Schumaker of Serere. On one occasion determinations were made of 98 samples, on another 133 samples. Agreement with Kjeldahl nitrogens have been found to be reasonably good. So, the method would seem to provide a rapid measure for protein where approximate values will suffice.

Kjeldahl nitrogens determinations were performed for Dr. Benaya Majisu, E.A.A.F.R.O., on 72 samples representing four replications of nine diploid-tetraploid pairs.

Early in January 1970, quantities of some sixty different sorghums were provided for our use by Dr. Hugh Doggett, Serere, Uganda. These will be tested and studied to differentiate the sorghums particularly for those factors which relate to food quality and processing characteristics.

As already mentioned the Home Economics Department of University College, Nairobi, is helping with evaluations of cooking characteristics. We, of course, intend to run proximate and amino acid analyses. We plan to make some simple tests requiring small samples which hopefully may provide information on the grains useful for predicting processing characteristics.

One such test is hardness. This was performed on an instrument borrowed from Mr. Ken Rachie of the Faculty of Agriculture Makerere University, Kampala, Uganda. Pressue is applied to a single sorghum grain placed on a platform and screwing down on a plunger. The increasing pressure

is indicated on a dial. When the seed breaks the pressure decreases abruptly leaving a maximum reading needle to indicate the breaking strength (i.e. the hardness). Ten or twenty grains are tested for each sorghum. There is considerable variation within the grains of a single sample but the mean values do seem to relate to our characterization of endosperm type arrived at by cutting and visual inspection. Ninety percent of all sorghums characerized as corneous had average hardness about 5 Kg/cm^2. Eighty four percent of those classed as floury broke below 5 Kg/cm^2. Those characterized as intermediate all broke between 3.2 and 7.4 Kg/cm^2. The entire range for mean hardness was found to be 2.0 and 12.0 Kg/cm^2.

Average kernel weight has also been measured on 300 kernels of each sorghum. The range found was from 13.6 to 40.3 milligrams. It would appear that the heavier kernels tend to have floury endosperm and the lighter ones corneous.

SUMMARY

West Africa

The Third African Cereals Conference sponsored by OAU-STRC was held at the Ahmadu Bello University, Institute for Agricultural Research, Zaria, Nigeria, October 13-16, 1969. Seventy delegates and observers from 19 countries were in attendance. The papers presented will be published in African Soils (Sols Africains). The delegates meeting as an Advisory Committee adopted a series of recommendations. These are presented on page 9 of this report.

Regional travel related to this project was performed in Niger, Camerouns, Ghana and Congo (Kinshasha).

Project staff located at both Zaria and Ibadan, have been responsible for supervision and training of students at both the undergraduate and graduate levels.

Regional sorghum trials were initiated in 1966. Based on experience in 1966 and 1967 separate trials were established in 1968; one series for the Guinea Savanna and a second for the drier Sudan Savanna.

Regional trials for bulrush millet in the Sudan Savanna were initiated in 1969.

Maize regional trials were continued with four countries participating.

Maize improvement in Nigeria is conducted at three locations, Samaru, Mokwa, and Ibadan. Maize is a new crop in northern Nigeria with potential for high yields. Composites are being formed and evaluated in hybrid combinations. Yields in excess of 7,000 pound per acre (127 bushels) have been obtained. Further improvement in genetic potential can be expected.

The genes opaque-2 and floury-2, which condition improved protein quality are being incorporated into the important maize breeding populations.

Disease susceptibility is an important factor limiting maize yields in high rainfall areas. Simply inherited systems conditioning resistance to the two most important leaf diseases (Southern leaf rust and Southern leaf blight) have been discovered and are being introduced into the breeding populations.

Management may be the most important yield limiting factor. In much of northern Nigeria maize yields may be essentially zero in the absence of applied phosphorus. When phosphorus is adequate nitrogen becomes limiting. Potash becomes limiting on soils which are heavily cropped with little or no additions of dung, ash or refuse from the compounds. Magnesium, molybdenum and boron appear tobe limiting on some soils. Much work remains to be done before an efficient package of agronomic practices is available for maize.

Sorghum breeding at Samaru has given main emphasis to dwarf types adapted to the Guinea Savanna. Improved selections are available which give yields increases ranging to 70 percent. Hybrids are available which exhibit even greater yield increases but seed production remains a problem due to disease problems.

In population density studies maximum yield was obtained at 54,540 plants per acre with a significant reduction when stands were increased to 76,230 plants per acre. Planting dates, ranging from 24 May to 21 June gave little differences in yield. Planting either before or after these dates gave significant yield reductions.

In the Sudan Savanna area the American hybrid NK 300 gave yields nearly 4 times the local check. Some of the early Samaru hybrids gave yields equal or better than the check hybrid NK 300.

Date of planting studies indicated a gradual reduction in yield as planting is delayed after the onset of the rainy season. Each work delay in planting gave a yield reduction of approximately 400 pounds.

Shoot flies are a serious problem on sorghum. Seventy-nine species have now been identified of which 25 have been reared on cereals. The systemic insecticides phorate and disulfaton have given good control.

Leaf diseases are serious on sorghums. The World Sorghum collection is being screened for anthracnose, sooty stripe, oval leaf spot, zonate leaf spot, and downy mildew. All four of the known smuts occur in Nigeria, yield losses are estimated to be 8 to 10 percent annually. Seed treatment could control such losses but this practice is not generally used. Genetics sources of resistance to the smuts is being sought in the World Collection.

Ergot, one of the serious barriers to hybrid seed production can be controlled by spraying at 3 to 5 day intervals with Benlate, Thiabendazote and Captan. Such treatments, however, would not be feasible in seed-production fields.

The objectives in the bulrush or pearl millet breeding program are to combine high yield with resistance to lodging, profuse tillering and resistance to downy mildew and smut.

Tift 23A, a cytoplasmic sterile from the United States, is quite susceptible to downy mildew. This type has been crossed to local and exotic types and selection practiced in segregating generations to develop new A lines having resistance to downy mildew and other diseases of importance. Bulks of some of this material gave yields higher than the Ex-Bornu standard. If the disease problems can be solved commercial high yielding hybrids will be a definite possibility.

Downy mildew is the most serious disease of pearl millet in West Africa. Some progress is being made in the isolation and identification of resistant types.

Smut and ergot are of limited importance except on introduced materials which generally appear to be highly susceptible. Techniques providing a more effective screening for resistance are being sought.

One striking phenomenon, common to all cereals, is the pronounced response to applications of dung. The response cannot be satisfactorally explained on the basis of N, P and K added. Studies on soils from long-term fertilizer plots indicate that dung has a pronounced effect base exchange capacity which may well effect the availability of both macro and micro-nutrients. As dung is not available in the quantities required extensive studies on the effectiveness of crop residues need to be initiated.

East Africa

Regional Conference - The Third East African Cereal Workers Conference was held at Zambia and Malawi on March 10-15, 1969. The Conference was attended by 43 scientists representing 10 countries. The main emphasis of the Conference was directed toward methods of breeding, agronomic research, extension grain legumes and regional cooperation.

East African Regional Maize Trials - Regional maize trials were initiated in 1966-67. The 1967-68 trials were grown at several locations in 7 countries in East Africa, Ethiopia, Uganda, Kenya, Tanzania, Malawi, Zambia and Congo (Kinshasha) and in Nigeria. The results from the regional trials have indicated the general areas of adaptation of the hybrids and composites under test and have also indicated the general superiority of the hybrids. On the basis of data now available each country can proceed with a hybrid program as

rapidly as they desire, having confidence that the program can be based on materials substantially superior to the locally grown varieties.

Data from the 1968-69 regional maize trials are currently available only for Kenya.

Diallel trial data are being obtained involving all of the composites used in the East Africa breeding programs. These results will provide additional background information useful in the development of more efficient local programs.

Training - Mr. Omalo completed the B.S. and M.S. degrees at Iowa State University and has returned to Kitale, Kenya to assume responsibility for the protein quality work.

Three members of the Kitale Maize Program Staff are currently working on advanced degrees through an arrangement with Makerere University. Provision for further training of other staff members should be made as soon as possible.

Maize Breeding - The Kenya Maize Program includes breeding work under three differing ecological conditions; Kitale - long season, high elevation; Embu - medium season, intermediate altitude and Katumani - short season. Hybrids are available and used extensively for the first two areas listed. Improved composites are most widely used in the area requiring short-season types. This area has a heavy population density but yields are much lower than in the more favorable areas.

Progress is being achieved in the breeding method studies designed to provide higher yielding foundation stocks.

The acreage devoted to hybrid maize has stabilized at approximately 250,000 acres. Substantial increases above this figure are not likely until maize is grown for other than food purposes.

Approximately 37,000 acres of Kenya developed hybrids were utilized in other eastern African countries. Opportunities for further expansion in this segment are great.

Sorghum Breeding - Work continues on population improvement and in the production and evaluation of hybrid combinations. The best experimental hybrids now available give yields approximately 45 percent greater than the best improved varieties.

Millet Breeding - Breeding work is underway on both finger and bulrush millets.

Regional trials within Uganda indicate significant differences among the varieties under test with a strong indication of an important variety x location interaction. The highest yield obtained under good management practices was 4460 pounds per acre.

A strain improvement program is underway to incorporate resistance to the blast disease. Preliminary information indicates that protein from finger millet is high in the essential amino acids, lysine, methionine and tryptophan. Greater emphasis on breeding for improved protein percentage and quality would be desirable.

Bulrush millet breeding is directed toward population improvement with the intent of using the improved populations to produce commercial hybrids.

A locally developed sterile Serere 102A appears to be superior to Tift 23A from the United States.

Cereal Agronomy - Date of planting trials with finger millet indicated that late February was optimum.

Planting trials involving bulrush millet in the second rains period, indicate the superiority of early planting, August 27 to September 10.

Early planting of sorghum, February 26 to March 12, gave higher yields than later plantings.

Fertilizer response varied somewhat with crop and location. With finger millet at Serere a large response was obtained for P but no response for N.

In fertilizer trials on farmers fields both N and P gave significant increases. Amount and distribution of rainfall probably obscured fertilizer response.

In sorghum and maize trials population density had little effect on yield level. Phosphate response was observed in both crops but N response was variable. More work is needed to develop an adequate set of agronomic recommendations for farmer use with the different crops in the different ecological areas.

Cereal Processing - Representative samples of sorghum were milled to establish characteristic yield of milling separates and their proximate composition. Floury endosperm types appeared to give higher than average flour and bran yields. Differences were noted among samples in retention of protein in the flour fraction.

The same samples were subjected to treatment with a CeCoCo rice polisher. This procedure was effective in pericarp removal but where testa color was involved, the resulting product was mottled in color.

Wet peeling was explored using caustic soda solutions. Pericarps were effectively removed but testa color remained a problem.

Extensive milling studies were performed using the varieties CK 60 and Sagena. The "break" and reduction yields of flour were substantially higher with Sagena emphasizing the importance of varietal differences.

A whole grain polished product was developed using the CeCoCo rice polisher. For this use a white seeded variety with colorless testa and corneous endosperm is required.

Cooperative arrangements have been made with the Home Economics Department, University College, Nairobi to develop recipes utilizing products from the milled sorghum products. Recipes have been developed and evaluated and thirty-three of these have been compiled in booklet form. Some of these were distributed at the Nairobi Fari with favorable acceptance.

Amino acid analyses were performed on opaque$_2$ and normal maize and on sorghum samples. Differences were noted among the sorghum samples for lysine, histidine, arginine, threonine, leucine, isoleucine and phenylalanine.